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CONCERNING TUCKSTONES

By JOSEPH EARLY
Amsler-Morton Company

THE proper construction of the connection between the silica sidewall and the flux block, commonly known as the tuckstone, is one of the many problems in the building of a glass melting tank. This problem has required thought since the beginning of continuous tank glass melting practice, and the various tuckstones and tuckstone connections described herein will give an idea of the many possible solutions to this problem.

Although many of the failures of glass melting tanks usually occur at the melting line; i.e., at the surface of the glass, there is a lack of published information on this subject. The Findlay Clay Products Co., however, have issued a well-thought out two-page pamphlet on the subject during the past year. Failure at the metal line is usually due to the eating away of the tops of the flux blocks by the glass, while the silica sidewalls remain in good condition. Some provision must therefore be made for the easy replacement of the worn flux blocks. This brings out the primary and basic requirement for the tuckstone connection: that is the support of the silica sidewall in a simple manner, while the flux blocks are being renewed. An inspection of some of the earlier sidewall and flux block connections reveals that this requirement was understood at an early date in tank glass melting practice, and that provision was made to satisfy it.

There are several other inherent requirements which must be met by the tuckstone. In bringing a tank up to its operating temperature from a cold state, there is an appreciable difference in the rate of expansion of the various materials used. If the silica sidewall brick or the tuckstone were resting on the flux blocks and the tops of the flux blocks were not allowed to move as the bottom blocks expand, the flux blocks might be very badly tipped. This condition is remedied by constructing the silica sidewalls in such a manner that they are supported independently of the flux blocks. This permits the flux blocks to remain in a normal vertical position. This requirement is particularly important in the wide window glass tanks in which there is as much as two inches expansion in the bottom blocks.

The tuckstone must also protect the tops of the flux blocks from exposure to the batch fumes and the high flame temperature, both of which cause rapid erosion. An explanation of this erosive action is in the formation of a thin highly viscous glassy material on the surface of the flux block which is in contact with the glass. Below the metal line, the temperature of this layer is sufficiently low that it remains in place and provides an excellent protection for the block. At and above the metal line however, the higher temperatures combined with the chemical action of the batch fumes produces a glass the viscosity of which is lowered to such an extent that the material constantly runs away and exposes fresh block surface to erosion. There are two solutions to this problem: 1. Changing the block composition so as to produce a glass of such a high viscosity that a large increase in temperature is necessary to lower the viscosity to the point where the glass flows freely or; 2. Cooling the tops of the flux blocks so as to keep them below the temperature at which this viscous layer runs away. This latter point will be given further consideration in the discussion of an ideal construction.

As the tops of the flux blocks are eroded in service, the support given to the tuckstones by the flux blocks gradually becomes less and less until, in cases in which the connection is not properly designed, the tuckstones topple into the tank. This causes a premature shutdown or, at least, a hot patch, until the flux blocks finally fail. Thus it is necessary to have a tie or support between the tuckstone and the silica sidewall so that the tuckstone will be kept in place even though the top of the flux block is entirely worn away.

In addition to the foregoing requirements there are several other desirable features to be considered. In the tuckstones which are shown, it is very desirable that the connecting line between the silica brickwork and the flux blocks be easily reached with cooling air in order to reduce the erosion at this point. This position should also remain accessible to permit the placing of water coolers or other means of stopping leaks.

FROM an economic standpoint, both the supporting structure and the refractory shapes used in the connection should be of standard shape. This is especially important when rapid repairs have to be made, as it requires considerable time to procure special shapes. There are, however, many cases in which special shapes are acceptable because of unusual conditions. In this case it is well to have the desired shapes in stock.

Expressed simply, the requirements of a tuckstone are: support, flexibility, simplicity, protection, accessibility.

The accepted practice in most glass tanks is to have an offset of 10 to 12 inches from the inside edge of the

silica sidewalls to the inside of the flux blocks in order to provide sufficient room for the structural braces which are deemed necessary to retain the flux blocks in position. Such a wide offset, while it makes for ease of support of the sidewall, causes a thermal loss as well as a loss of potential production.

Considering a tank which is 25 feet wide and 30 feet long, having a melting area of 600 square feet with the standard 12 inch offset; if the flux blocks are moved back or out until they are flush with the silica sidewalls, the width of the tank will have been increased to 22 feet and the length to 31 feet with a melting area of 684 square feet. This results in an increase of 84 square feet in melting area without greatly increasing the initial cost of the tank or radically changing the construction. This change can be easily incorporated in present equipment, and should require little additional fuel consumption per ton of glass produced because the radiation surfaces will be only slightly larger. Taking 10 square feet of melting area per ton of glass produced, an increase of eight tons of glass daily should be possible through this proposed change. Such a construction is a departure from accepted practice (a step that some manufacturers are reluctant to take) but the necessary structural changes require only a small additional outlay of money, which should easily be returned in the first month's operation because of the additional tonnage that can be pulled.

In constructing this flush type of connection it would be desirable to provide a 15 or 18 inch silica sidewall above the glass line. This additional thickness (except for window glass tanks which already have thick sidewalls) would lessen the heat losses through the silica sidewalls and also provide more room for structural supports for the flux blocks. This construction is given in Group 6 (f, g, h).

THE supporting buckstays in all cases shown, consist of two channels placed back to back and held one and one half inches apart by fillers. The size of the channels used is indicated in most cases. Most of the connections are shown with the silica brickwork supported by angles of varying sizes, and held in place by one of two methods: 1. The angle is bolted to the outstanding legs of the two channels composing the buckstay by two five-eighths inch bolts or, 2. it is held in place by a long bolt through a slotted hole in the leg of the angle between the channels of the buckstay. If it is desired, a small strap may be welded to the legs of the channels at the point where the angle is to be located in order to give additional support to the angles. The long bolt method seems most desirable as it provides sufficient strength and at the same time sufficient flexibility to take care of any movements in the structure.

Some of the supporting structures shown in the accompanying sketches will be discussed.

Group 2 (b). This is a heavy iron casting bolted between the buckstay channels with a heavy bar shaped casting sitting upon them in short sections between each individual buckstay. This is expensive but justifiable because of the unusual conditions met with in window glass tank practice. See notes under the sketch.

Group 3 (b). This support is composed of two angles with their outstanding legs cut off. It is bolted in place between the channels of the buckstay to form a knee upon which a channel is lying. This makes it necessary to cut the outside leg of the channel off at the buckstay where the supports are. This construction is not desirable as it decreases the strength of the channel. One frequently used older construction is similar except that a casting shaped to fit the channel is used instead of the angles. This makes a satisfactory support.

GROUP 4 (b). This supporting structure consists of a bar placed between the channels of the buckstay and bolted in place with a plate or casting sitting upon it. This is satisfactory if care is taken that the casting is made heavy enough. This plate casting has been used with the angle knees in the Group 3 (b).

Group 4 (c). The angle supports are shown in the sketch but, instead of a plate casting, two four-inch I beams are used to support the silica sidewalls. This is satisfactory as a support but its disadvantages will be found under the discussion of this type of connection.

Group 4 (d). This is similar to Group 4 (c) but with an additional channel in a horizontal position under the I beams. Unless the spacing of the buckstay is exceptionally wide this construction is not to be considered. Instead of adding the channel it would be much better to use a larger section I beam so as to obtain additional strength.

Group 4 (e). This is an angle section casting with an ear bolted between the buckstay channels. This is not desirable as it does not provide the necessary flexibility for free movement of the buckstays.

Group 4 (g). This is another example of the use of an angle casting. These are made up in short sections and bolted to the individual buckstays much the same as the steel angles. This construction is not recommended because new patterns are needed for every job and the extra cost makes it more expensive than steel without its compensating values.

Group 5 (h). This construction consists of a bent steel bar which is bolted onto the buckstay and upon which are laid four two inch I beams. This supporting structure entails additional expense without any compensating values and is not recommended.

THE sketches are shown only with the commonly used standard materials of construction. While there are numerous super-refractories which may be used in many combinations and shapes their selection is a matter for individual manufacturers.

In the sketches, the double lines with a wide space indicate the silica sidewall brickwork or shapes. The single spacing indicates the refractory tuckstone and the criss-cross lines indicate insulation. The solid and dotted line combination shows the flux blocks, and the close sectioning, the supporting structure. The metal line or glass surface in all cases is assumed to be from one to two inches below the top of the flux blocks unless otherwise noted.

GROUP I—*Refining End Connections.*

This group of connections consists of those used in the nose or working end of the tank. Because of the lower

temperatures and the absence of fluxing fumes in this portion of the tank it is not essential that the blocks be cooled or that they be well protected on their upper surface.

(a). Working and tuckstones have the same major requirements of silica sidewall support as those in the melting end. In some working ends, particularly those which are hand worked and in which the temperature is not much over 2150°, it is desirable to add common red brick or insulating brick to the outside of the flux blocks. This makes the surroundings cooler for the hand gatherers to work. The insulation is applied much as is shown in the sketch. Where the temperature is much higher, insulation is not especially desirable because the glass has a tendency to run out between the joints. Such a condition is also a possible source of stones.

The connection as shown attempts to support the silica sidewall but it is not satisfactory as the angle is inside of the insulation. Protection is provided the tops of the flux blocks although it is not entirely necessary. This simple connection is not recommended because of the improper location of the structural support for the sidewall.

(b). This connection uses a 12 inch silica sidewall instead of the usual nine inch type and adequate provision is made for holding the silica sidewall during re-blocking. This connection would prove satisfactory for the service required.

(c). This construction shows a 12 inch silica sidewall used in connection with a 12 inch flux block without making provision for the support of the sidewall during re-blocking. Although there is little erosion of the flux blocks in the nose end and the re-blocking is infrequent, this connection fails to provide sufficient silica sidewall support and is not to be recommended.

(d). This connection also has 12 inch walls but provision has been made for silica sidewall support during re-blocking. The silica sidewall has been set up three inches and a standard brick is slipped in place after the tank has been brought up to operating temperature. This connection has merit and is to be recommended.

Failure of nose end flux blocks usually occurs at the metal line in the same manner as the melting end blocks but a longer period of time is required. Accordingly less provision is made for cooling the blocks in this position because of this longer period of operation. It would seem very desirable however to make some effort to use cooling in this region as the life of the nose end flux blocks should be materially increased.

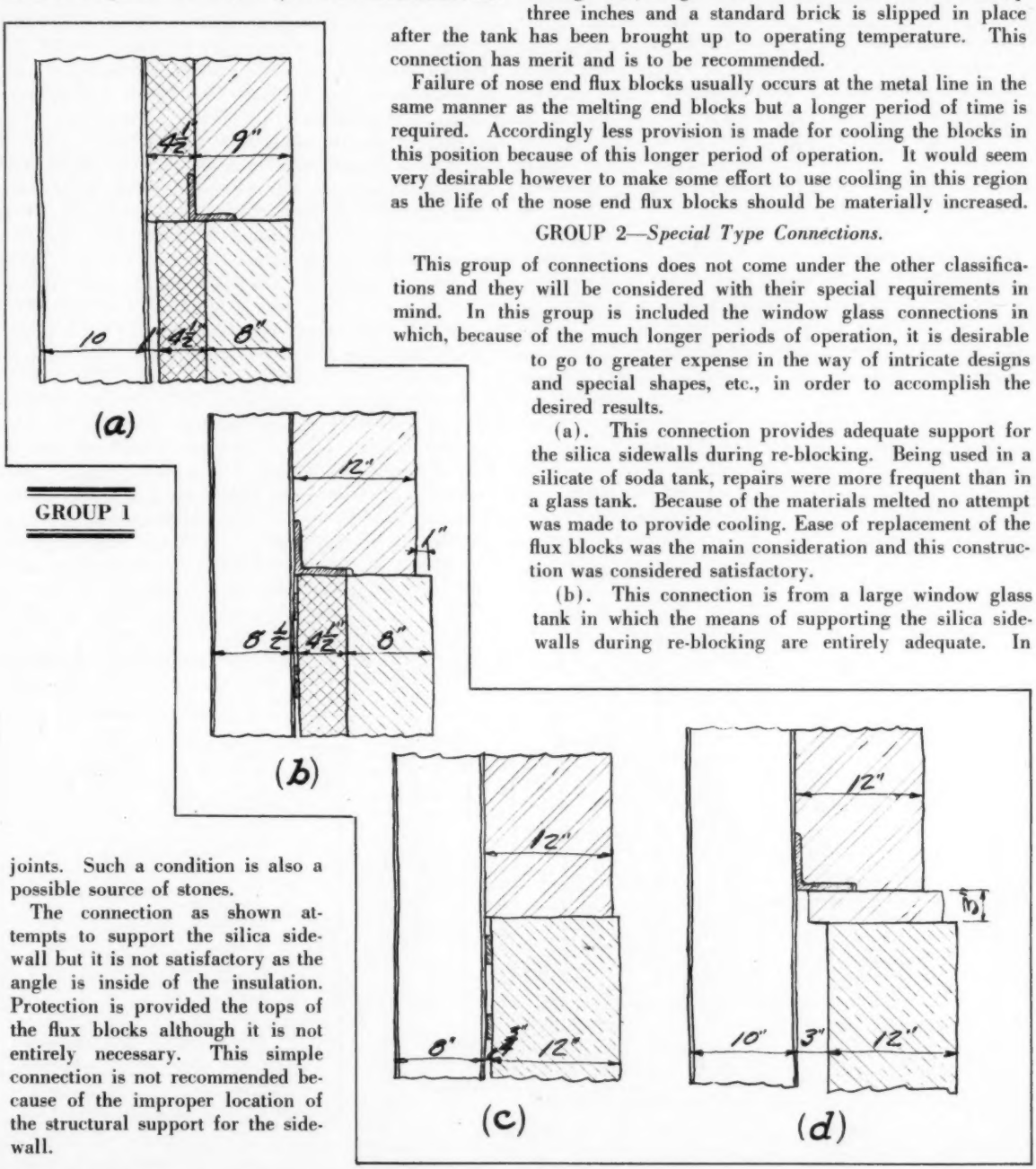
GROUP 2—*Special Type Connections.*

This group of connections does not come under the other classifications and they will be considered with their special requirements in mind. In this group is included the window glass connections in which, because of the much longer periods of operation, it is desirable to go to greater expense in the way of intricate designs and special shapes, etc., in order to accomplish the desired results.

(a). This connection provides adequate support for the silica sidewalls during re-blocking. Being used in a silicate of soda tank, repairs were more frequent than in a glass tank. Because of the materials melted no attempt was made to provide cooling. Ease of replacement of the flux blocks was the main consideration and this construction was considered satisfactory.

(b). This connection is from a large window glass tank in which the means of supporting the silica sidewalls during re-blocking are entirely adequate. In

GROUP 1



practice, because of size, the tanks are operated for long periods without shutdowns for repairs. As can be seen, the tops of the flux blocks are easily accessible for cooling and for the many hot repairs which must be made at the metal line. At times the entire top row of flux blocks is replaced which makes accessibility imperative. In this connection 20 inches of the top of the flux blocks are exposed and should be protected in some way since window glass batches all contain salt cake which as is well-known, is especially corrosive to flux blocks. Due to this lack of protection, this connection cannot be fully recommended.

(c). This window glass connection seems much more desirable than the preceding one as it satisfies the major requirement of silica sidewall support during re-blocking. Adequate provision has been made for cooling the tops of the flux blocks as well as for accessibility for making hot repairs when necessary. A pipe water cooler is placed on the tops of the flux blocks to prevent their erosion, much as the application of air prevents it in the tuckstones which will be presented in Group 6. This connection is complicated because of the special shapes and the water coolers but where length of operation without shutdown for repairs and good quality glass is required, this additional expense seems justified. 18 inch sidewalls are used in most of these large tanks in order to lessen the large radiation losses. The use of the pipe water cooler introduces additional heat losses but it is believed that these losses will be overshadowed by increased life and fewer stones in the finished glass. This construction seems most desirable for the window glass industry.

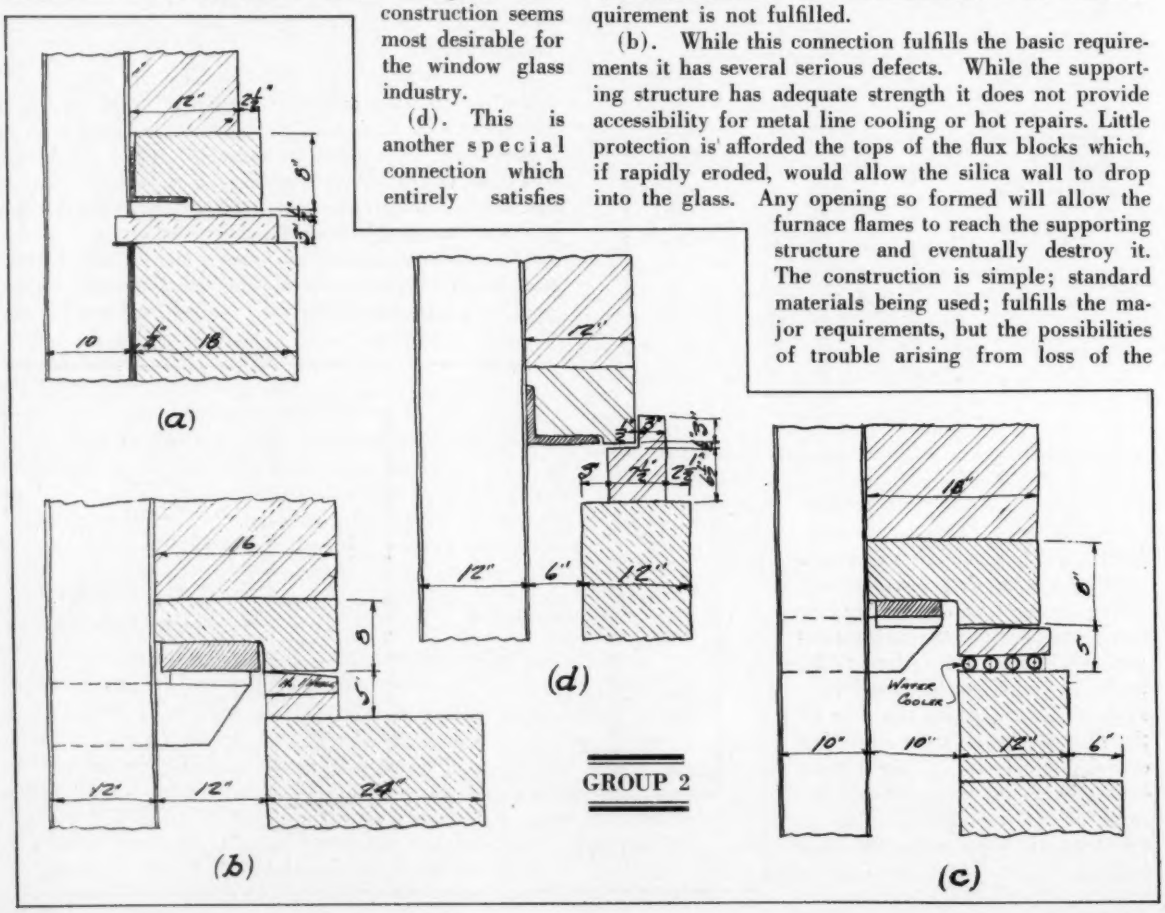
(d). This is another special connection which entirely satisfies the major requirement. It provides accessibility for cooling and hot repairs. Sufficient protection for the tops of the flux blocks is not provided and with a thin section there would be an appreciable heat loss. It is expensive to construct because of the special shapes required, and is not recommended for ordinary tank practice.

GROUP 3—*Silica Sidewalls in contact with Flux Blocks.*

This is the first of four groups of tuckstones used in the melting end of a glass tank. In Group 3, unlike those in the other groups, the silica sidewalls are in contact with the flux blocks in all the connections discussed, there being no clay or refractory shape used to keep them apart.

(a). This construction is from a large bottle tank in use a number of years ago. It does not fulfill the major requirements of a suitable connection as the silica sidewall is in direct contact with the flux blocks and would need rebuilding with every re-blocking. This construction is also dangerous as the breaking of the flux blocks through erosion may cause the sidewalls to collapse. The three inch overhang on the inside does reduce the erosion due to temperature of the flux block by protecting the block from the flame. This doubtless prolonged the period of operation of the tank. The construction provides accessibility for cooling purposes and hot repairs; protection for the tops of the flux block, and simplicity in that standard shapes only are required. The construction is not recommended as the basic requirement is not fulfilled.

(b). While this connection fulfills the basic requirements it has several serious defects. While the supporting structure has adequate strength it does not provide accessibility for metal line cooling or hot repairs. Little protection is afforded the tops of the flux blocks which, if rapidly eroded, would allow the silica wall to drop into the glass. Any opening so formed will allow the furnace flames to reach the supporting structure and eventually destroy it. The construction is simple; standard materials being used; fulfills the major requirements, but the possibilities of trouble arising from loss of the



GROUP 2

silica brick wall is so great that this connection should be avoided.

(c). This connection provides only partial support of the silica sidewalls and would doubtless require additional support during reblocking. It provides accessibility for cooling air and hot repairs but does not provide proper protection to the tops of the flux blocks. As the flux block is only eight inches thick such protection is especially desirable. While this connection is of simple arrangement and uses standard materials, the possibility of rapid erosion prevents this connection from being recommended.

(d). This connection is very similar to the preceding with the exception of the thickness of the silica sidewalls and is not to be recommended for the same reasons as the preceding connection.

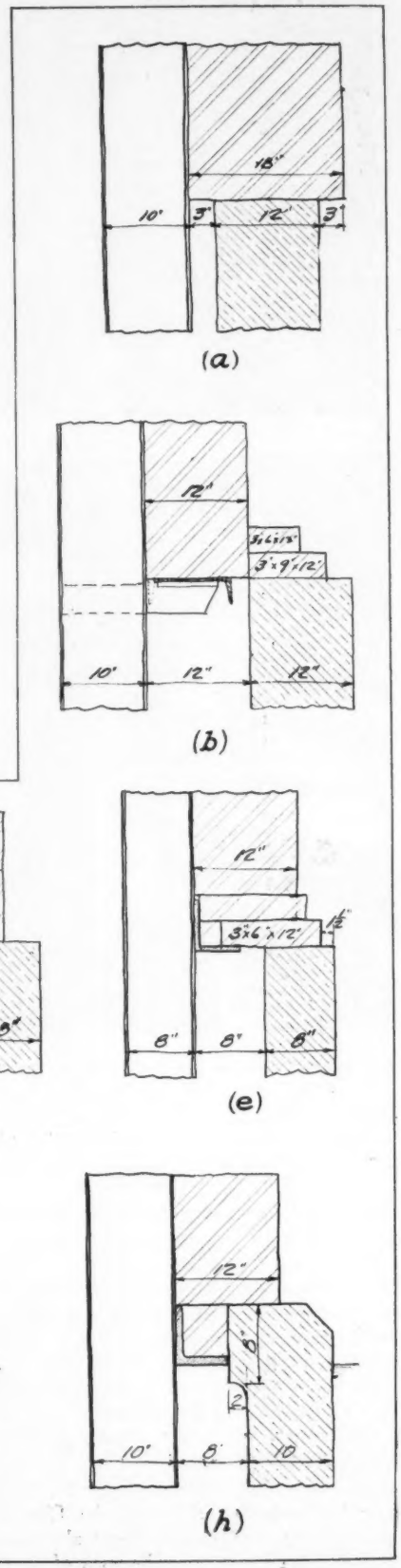
(e). This connection fails to meet the major requirements; provides only fair erosion protection; is easily accessible for cooling and hot repairs, is simple in construction and the three by six by twelve inch shape can be advantageously made of a special refractory material. The construction is not recommended however as the flux blocks cannot be replaced without disturbing the silcia sidewalls.

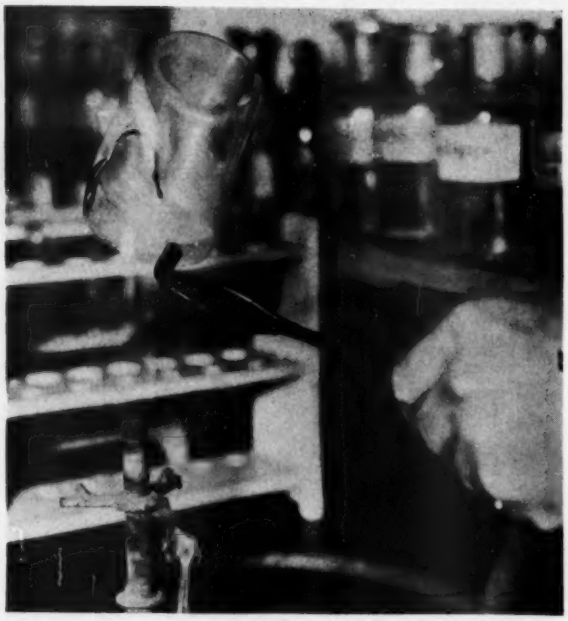
(f). This connection fulfills the major requirements and is simple in construction. While all but three inches of the tops of the flux blocks are unprotected the silica brick used for tucks are well tied in and should not topple into the tank if the flux block tops erode. This construction is better than the preceding ones in this group as it fulfills to the greatest extent the requirements of the tuckstone. If in this connection the metal line is down six to eight inches rather than one or two the additional wall height can be considered as taking the place of the refractory tuckstone. This will eliminate the parting line that usually exists and will prevent the marked erosion that occurs at this point. Such a construction also can readily be cooled and hot-patched. While such a construction has been used it is not to be recommended when ordinary flux blocks are used. Such blocks are not refractory enough to withstand the high temperatures encountered and the erosion at the metal line would rapidly undercut the portion above the metal line, which when weakened may topple into the tank.

(g). This connection indicates a further possibility of (f) in that one of the super refractories is cast in one piece. The major requirement is not met,

(*Cont. on page* 290)

GROUP 3





Germany has begun production on a new type of unbreakable "glass." It is made of artificial silk, and is extremely light in weight. The top illustration shows a piece of artificial silk about to be metamorphosized into glass. Below, showing how a flame will melt but will not ignite this glass.

ERRATA

Two errors were made in reproducing illustrations in the August number of The GLASS INDUSTRY. In the article "Results via Scientific Control" by H. K. Richardson, there were shown pictures of a heatless conveyor and of a heated conveyor on pages 234 and 235. These illustrations became transposed. Fig. 3 is the heated conveyor and Fig. 5 the heatless conveyor.

In the paper "Adherence of Glass to Metals," by Nelson W. Taylor, on page 243 is shown an illustration of a Cathetometer, which the caption erroneously describes as a Calorimiter.

The Fifteenth Exposition of the Chemical Industries, familiarly known as "The Chemical Show," will be held in New York City during the week of December 2.

STERLING SPENDS $65,000 MODERNIZING FACTORY

New machinery, additions to factory building, and the rearrangement of production lines, were part of an extensive modernization program that was completed in August at the Lapel, Indiana, factory of the Sterling Glass Company. The changes will add considerably to production capacity and facilitate the handling of materials in and out of the plant, giving the company what it considers the most modern factory in its line and of its size, in that part of the country.

A new building has been erected for mold storage and to accommodate a maintenance department, the latter being quite new, as hitherto all repairs to factory equipment have been done outside. The office building has been enlarged. Existing warehouse space has been extended and provided with a concrete loading platform, and this will soon be supplemented by a second 90 x 120 new warehouse building to accommodate finished stock. Of the new machinery installed, the most important, perhaps, are four new Amsler-Morton lehrs, replacing old ones that have been in service some 25 years.

Sterling Glass Company was acquired some eleven years ago to provide the glass containers requirements of the Warfield Chocolate Company and the Thomson & Taylor Company. In the course of time a large outside business has been developed, particularly standard and private mold packages that permitted long runs. Lee Sanford is factory manager.

The production of Polished Plate Glass for the month of July, 1935 was 13,908,529 sq. ft., as compared to 13,162,515 sq. ft. produced in June.

KIMBLE GLASS PLANT BETTERMENTS

The past month has seen the completion of several new buildings at the plant of the Kimble Glass Co., Vineland, N. J. A furnace building and a three-story warehouse are both new, while the engine and boiler room has been entirely renovated. These improvements will result in adequately housing existing equipment that heretofore was not advantageously located.

The new main furnace building is 132 x 100, of steel frame covered by corrugated sheeting, and provides space for three producer gas melting tanks that can serve eight Darmer machines. One of these tanks is now in operation and another in process of construction. The warehouse is 132 x 140, of steel frame faced with brick, and adjoins the furnace building, so that the first floor may be used for drawing operations. A complete basement provides storage space for rod. Simplex Engineering Company was the contractor.

GLASS RAZOR BLADES

Glass razor blades are being made in Czechoslovakia. Reports state that by means of a new process, the new glass blades can be made as flexible and as sharp as those made from steel, and they can be produced more cheaply.

The annual convention of the Illuminating Engineering Society will be held in Cincinnati, September 3 to 6, at the Netherland-Plaza Hotel.

PERFORMANCE HISTORY OF GLASS TANKS

By J. W. ROMIG

CHANGES in design of glass tanks are frequent and sometimes they are made without adequate grounds. One of the reasons for needless changes or changes that do not pay for themselves is that histories of performance of tanks are not properly maintained. A second reason is that actual performance comparisons are not prepared. Each fundamental change in the construction of a tank should be recorded and the performance comparison will show the results, if any, of the change.

Fundamental changes may include operation as well as design, material and construction. Operation changes of importance include temperature of fuel gas, if producer gas, furnace pressure, draft, blowing of checkers, cleaning flues, repairing leaks, melter temperature, refiner temperature, distribution of fuel in combustion chamber, etc. Design and construction changes are usually made during a shutdown although hot repairs, such as replacing checkers, may change some operating fundamental. The height of the crown, the area of ports, number of air checkers and spacing, number of gas checkers and spacing, dimensional changes and material changes may or may not affect performance.

Records should be made easy to summarize and should be so that a complete history of a tank unit can be secured showing not only all changes but the results.

Table No. I

Melter length, width and depth
Melter volume
Refiner length, width and depth
Refiner volume
Crown height. Number of Ports. Port Dimensions.
Inside length, width and height of air generator
Inside length, width and height of gas regenerator
Type of stack, height and diameter
Type and size of air valve and gas valve
Canal areas
Refractories and thicknesses
Length of time of tank operation
Number, weight and height of air checkers
Number, weight and height of gas checkers
Checker spacing and height
Type and material of checker brick
Length of check service
Temperature melter
Temperature refiner
Stack temperature
Furnace pressure
Refiner connections
Kind of glass
Fuel Distribution
Producer gas temperature
Producer gas pressure
Draft
Normal tank pull
Continuous maximum pull
Operating schedules
Waste gases

The changes are usually better remembered than the results after a couple of years elapse. Inadequate records may mean costly repetition.

The performance comparisons have a secondary use that may become primary in formulating a design program for units that function well may be compared with those that do not produce proper results. In most any plant having two or more tanks there will be one unit that is reported to work better than the others. In some cases whether the favorite unit is really better or the idea that it works better is fancied may be determined to a greater degree of accuracy through proper records. Such data, if properly assembled and maintained, will lead to a better understanding of the important phases of design, construction and operation.

A tabulation of the most important items entering into performance is shown in Table No. 1. Other items may demand attention and be added if desired.

Table No. II

Fuel requirement, quality and amount
Maximum continued glass pull and type glass
Total glass melter and refiner
Melter and refiner temperature
Combined melter and refiner temperature
Melter temperature minus stack temperature
Melter temperature minus producer gas temperature
Fuel per square foot melter
Fuel per square foot melter and refiner
Fuel per ton air checkers
Fuel per ton gas checkers
Fuel per ton total checkers
Fuel per ton glass total
Fuel per ton maximum continued glass pull
Velocity flame across tank
Tons glass per ton air checkers
Tons glass per ton gas checkers
Tons glass per ton total checkers
Tons maximum continued pull per ton air checkers
Tons maximum continued pull per ton gas checkers
Tons maximum continued pull per ton total checkers
Fuel per cubic foot furnace volume
Fuel per square foot port area
Regenerator surface area per square foot melter
Tons checkers per square foot melter
Tons checkers per square foot melter plus refiner
Cost of complete tank unit
Cost per ton maximum pull
Fuel Cost per ton good product during Life of Tank
Repair cost tank unit to put tank in good condition after a run
Length of run
Repair cost per ton of glass pulled

In addition to the items in Table 1, a summary of interdependent major factors is desirable. The calculations in most cases involve only simple arithmetic. Table No. 2 shows items of particular interest that are found from information in Table No. 1. More detail can be developed if desired or in case the general tabulation should not account for variations between units.

Explanation of a few of the items in Table No. 2 is in order. The melter and refiner temperature combined is found by multiplying the melter temperature by the volume of the melter combustion space and adding this to the product of the refiner temperature and the volume of the refiner combustion space, then dividing by the total volume. While the combined temperature found is an approximation, it is closer to actual average combustion chamber conditions than either refiner or melter temperature.

Normal glass pull or rated capacity may be some standard pull set up according to dimensions of the melter. This figure varies in installations and it is necessary to determine the maximum allowable con-

tinuous glass pull from operation. This loading value indicates the potential pull value of the tank which, if exceeded, leads to production of glass that is not merchantable.

Items showing the fuel per ton of total checkers, the fuel per square foot melter and refiner total and the fuel per ton maximum allowable continuous glass pull are indicative of fuel performance, providing that the glass pull as defined above is well established. Comparisons of fuel per ton of glass pulled are misleading unless the basis of pull is established during the actual operation and that the same kind of glass is involved in making comparisons. A comparison of a high grade flint glass tank with a green bottle glass tank would lead to erroneous conclusions if based entirely on glass pull. The comparing of fuel per square foot melter and refiner after making temperature allowances, is a better basis for comparing fuel performances.

Tons of checkers per square foot melter and refiner total provides comparisons as to a deficiency or surplus of checkers. Stack temperatures are compared when checker conditions are similar. That is, with old checkers the stack temperature is not directly comparable with that in case of new checkers.

In the assembly of Tables Nos. 1 and 2 the great majority of items can be readily determined by measurement without special apparatus. Furthermore, theoretical details have been excluded in favor of physical comparisons wherever possible. At times, it may be desirable to go into very complete theoretical studies of tank performance, investigating velocities, pressure drops, localized temperatures, etc.

If the advantage of a change is not evident in comparing readily measurable physical quantities then the result is probably of minor consequence. Adequate records will often avoid "back tracting" and needless expense.

OPTICAL GLASS NOW USED IN SCALES

What has been described as one of the most dramatic examples of successful industrial research—the creation of the new Toledo Plaskon scale—was accomplished recently through the collaboration of six great companies, one of them the Bausch & Lomb Optical Co., Rochester, N. Y. Each one of the six companies contributed something new and revolutionary in their particular fields, and their combined efforts resulted in: a reduction in weight from 154 pounds to 55½; a chart that would not warp or bulge and containing 95,000 digits; a degree of sanitation never before attained; and the introduction of optical glass into the manufacture of scales for the first time.

Why optical glass? The problem was to accommodate 95,000 digits on the chart and make every one of them legible without distortion. In place of 30 prices per pound, 60 were desired (five times the number ever before used). The problem was solved by reducing the size of the figures to half size and then magnify them. This required a lens that would not only give desired magnification, but do it without distortion or color fringes.

The lens that was finally developed by Bausch & Lomb consisted of two elements cemented together; one

of them of crown glass with convex surfaces and spherical curves on both sides, the other of flint glass with concave spherical surfaces exactly matching the curve of the crown glass element and a slight cylinder on its other surface. The differences in refractive index and ratio of dispersion between the two glass correct the fault known as chromatic aberration, or the inability of a single lens to focus light of different colors at a single point. Equally important in this lens is the correction of spherical aberration, a condition in which the rays from a single source fail to converge at the same focus. In this lens the figures are seen as clearly through its margins as through its center. The result is a sharp definition of the numerals and scale intervals, without color or distortion, covering a large flat field of view. Approximately two-power magnification makes the numerals distinct from a distance of several feet. The scale is fitted with four lenses, 3″ long by 1¾″ wide, mounted in a rack covering the face of the drum.

The lenses for the new Plaskon scales are accurately figured to achieve specific results. Special molds were made to turn out the pressings. The grinding of these blanks presented many difficulties, because of their shape, size, and thickness, all of which have been overcome by special technique and tools.

The size and weight of the two elements has also presented problems in cementing. The fitting of the two lenses requires that the optical axis of each shall coincide with exactness. A special edging machine has been developed for this lens to overcome difficulties that developed because of the difference in the hardness of crown glass as compared to flint. The lens is given a very high polish resulting in a brighter image and a sharp contrast between the black figure on the white background.

DR. ANDREWS IN EUROPE

Dr. A. I. Andrews of the Department of Ceramic Engineering, University of Illinois, is visiting Austria, France, Germany, England, and Czechoslovakia. Dr. Andrews is making this business trip as a representative of a large American manufacturing concern dealing in ceramic materials.

CHEMICALS THAT ACCELERATE MELTING

GLASS manufacturers are exceedingly interested in the development of methods and chemicals that will accelerate the melting operation, because a quicker conversion of the batch into workable and salable glass results in increased production and lowered manufacturing costs.

While it is possible to accelerate the melting and refining of glass by materially increasing the melting temperature, furnace construction and refractory materials have not as yet reached a stage where this method is economically feasible. It is also possible to obtain a quicker melting batch when the batch is in the briquetted form or when the batch materials are of extremely fine grain size. In both cases the high cost of equipment for converting the batch into these forms is a drawback to their adoption. With fine grain size batch materials, the danger of their being blown about the furnace and down into the checker work is also a great disadvantage. When, and if, a furnace is developed that dispenses with the moving flame and heats the charge by indirect means, the use of fine grained batch materials may prove advantageous.

At present the only solution to the problem is the use of chemicals which, when added to the batch, accelerate the melting and refining stages without producing any undesirable secondary defects. In the last few years, several chemical accelerators have been subjected to complete investigation, both in the laboratory and in practice, with the result that their advantages and disadvantages are fairly well known.

The introduction of small amounts of borax into bottle glass to increase its durability is probably responsible for the discovery that its presence, even in these small amounts, materially decreases the melting and refining times. Schurtz[1] introduced up to 30 lbs. of borax per 1000 lbs. of sand into a glass batch which was being melted in a 50 ton side port tank; he conclusively proved that in actual practice the use of borax in the batch permitted greater tonnage of completely melted and seed-free glass to be pulled from the tank. Turner and his co-workers[2] in a series of laboratory tests added borax up to 50 lbs. per 1000 lbs. of sand to a batch of sheet glass composition and found that its use notably reduced the time required for the glass to become batch free. The difficulty of producing seed-free glass in these small scale experiments prevented the drawing of reliable conclusions regarding this point. A writer in Keram. Rundschau[3] in an article describing experiments with small amounts of borax also points out the accelerating properties of borax.

The use of borax as an accelerator creates no disadvantages. In fact, its use increases the durability of the glass, decreases devitrification tendencies and as has been noticed in practice and proven by Bowmaker's[4] experiments, its use actually reduces the quantity of selenium required for decoloration. In the discussion of Bowmaker's paper, A. E. J. Vickers remarked that he had found that the addition of small amounts of borax to a standard bottle glass materially reduced the viscosity at the melting temperature; decreased the surface tension and increased the melting rate of the glass. The increased melting rate was considered the cause of the decreased amount of selenium required for the decoloration as the selenium was trapped before it could volatilize.

The use of ammonium salts for accelerating glass melting was first systematically investigated by Turner[5]. Of the following three ammonium salts, sulphate, nitrate and chloride, he found that the chloride was the least efficient and the sulphate the most efficient for accelerating both the melting and the refining of the glass. Glasses containing the nitrate, while better than those with the chloride as far as the melting rate was concerned, were impossible to clear of a small fine seed. A comparison of the three salts and the parent batch is given in Table I. Nadell[6] found in practice that the use of ammonium sulphate in the batch increased production. His laboratory tests showed that a mixture of ammonium sulphate and ammonium nitrate was more efficient than the sulphate alone. Works tests confirmed this as the addition of about 20 per cent of the nitrate salt reduced the total amount of ammonium mixture required by one-half.

Turner and his co-workers[7] in a further investigation of ammonium sulphate found that, with between 5 to 10 parts of the salt per 1000 lbs. of sand the greatest efficiency was obtained; if more than 10 per cent is added the efficiency is lowered. Practical tests in the plant by Vickers, Whiting, Miller and Bates[8] showed that 0.7 per cent of ammonium sulphate in the batch gives quicker melting and refining in addition to other improvements such as greater homogeneity, etc. Samsonov[9] in addition to verifying Turner's work on the sulphate and the nitrate also used the carbonate but found it unsatisfactory.

The only disadvantage in the use of ammonium sulphate so far disclosed is its effect upon the color of the glass. Preston[10] found that its use in glasses colored with chromium compounds caused a displacement of the color from the yellow to the green. Preston also quotes

TABLE I.

Material*	Time Req. to become batch free (Min.)	Time Req. to become seed free (Hrs.)
Ammonium Sulphate	50	3.5
Ammonium Nitrate	60	Small seed throughout
Ammonium Chloride	75	8.0
Parent Batch	90	9.0

* All materials added at rate of 5 lbs. to 1000 lbs. of sand.

F. C. Flint as reporting that the presence of the salt modifies the effect of selenium. Turner[11] claims that when more than 7.5 parts of ammonium sulphate per 1000 lbs. of sand is present, additional selenium is required for decolorization as the volatile sulphate keeps the batch open and facilitates the escape of the selenium. This loss can be reduced if selenites are used instead of metallic selenium. (*Concluded on page 282*)

A SURVEY OF INSULATION PRACTICE*

By C. W. PARMELEE AND A. E. BADGER

THERE has been notable success with the insulation of high temperature parts of open-hearth steel furnaces. Since regenerative glass tanks are similar to such steel furnaces, the use of insulation for glass melting furnaces suggests itself. However, the crown of a glass tank is exposed to much more severe attack by alkaline agents than that of an open-hearth furnace and so insulation of glass furnace crowns has proceeded cautiously. Probably many glass tank crowns are still subjected to periodic sweeping by competent furnace operators in order to remove the dust which acts as an insulating blanket. This conservative attitude is probably due to the failures which resulted from early attempts at insulation.

Since a glass tank operates at a low efficiency (20 per cent efficiency is a high value), the opportunity for a large saving in fuel is obvious. Moreover, with modern refractories and insulating materials, the chances of success are much better today even in those furnace parts which are exposed to strong attack, as the flux side walls of the tank.

About ten years ago W. K. Brownlee became one of the foremost sponsors of insulated glass tanks. Some of his ideas were incorporated in glass tanks of various companies and other developments followed. However, the advantage of insulation of various furnace parts is still an open question.

In order to obtain a cross-section of the opinions of operating glass men regarding the controversial subject of insulation, a questionnaire was circulated among a number of glass works.

The value of insulation on such glass plant equipment as lehrs, mold ovens, glory furnaces, pot furnaces, and day tanks was considered proven. The questionnaire which was prepared referred to continuous glass tank furnaces.

More than 50 replies were received to this questionnaire. Since many of the replies omitted parts of the questionnaire, there were on the average about 30 replies to each question.

The three questions which were placed on the questionnaire will be considered in order in the following account.

1. *Do you advise the use of insulation on the following furnace parts: melting end crown, refining end crown, melting end flux side walls, refining end flux side walls, melting end bottom, refining end bottom, regenerator walls, necks (uptakes), ports, recuperator walls?*

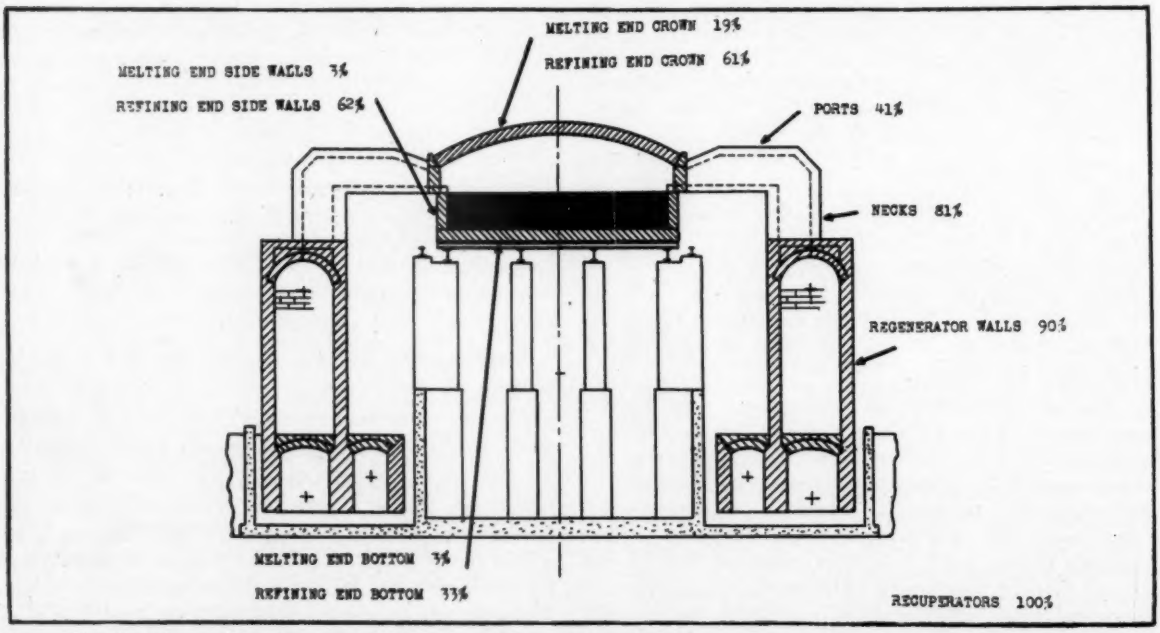
a.—*Melting end crown*

There were 25 opinions against insulation of the crown and 6 in favor. The predominant opinion, therefore, was that silica brick would not stand up under the conditions in the melting end. There would be too much danger of the crown falling in or at least having a shortened life. Trouble due to crown drippings would be aggravated also.

Fire coming through the crown was another difficulty which was mentioned. One manufacturer prevented this trouble by placing a plastic layer of silica mortar between the crown and the insulation.

Two negative replies admitted that time may change their opinion, one of these mentioning the encourage-

* This is a summary of replies to a questionnaire which was submitted to the glass trade, as compiled by the authors. Presented at the Third Conference on Glass Problems, Department of Ceramic Engineering, University of Illinois (Urbana, Illinois, June 1, 1935). Published with the permission of Dean M. L. Enger, Director of the Engineering Experiment Station, University of Illinois.



Results of questionnaire on the insulation of glass tanks, showing percentages of replies favorable to its use.

ment which may be derived from experience with the insulation of open-hearth furnace crowns.

Of the affirmative replies, one stated that only the part of the melting crown beyond the second port should be insulated. (The number of ports was not stated, but it might be three.) Mention was made also that insulation of the melting end crown would not only save fuel but would improve conditions for silica brick.

b.—*Refining end crown*

Regarding the insulation of the refining end crown, the majority ruled in favor of it (18 *Yes*, 11 *No*). However, the opinions were quite evenly divided, for many of the affirmative replies were not enthusiastic. One reply stated that it would be desirable to experiment with a small tank, and others recommended it only for the smaller units which operate at more moderate temperatures. Others recommended insulation only in case the temperature was too low for proper fabrication (as might exist in some sheet glass tanks).

Another reply favorable to the insulation of crowns stressed the limitation of structure. Very wide crowns may not expand uniformly and it is wise to leave such crowns exposed in order to watch their movements during heating and cooling periods.

The negative replies mentioned the possible shorter life of the crown and the danger of failure. These risks were not counterbalanced by the small saving in fuel which could be expected.

c.—*Melting end flux walls*

The opinion was overwhelmingly *No*, there being 29 negative to one affirmative, and the latter contained the qualification that the insulation be applied only half-way up the blocks (Corhart). Two of the negative replies mentioned the possibility of insulation if special blocks were used, the joints between the blocks being left open.

These negative replies were expected, of course, since air cooling is widely used to decrease the corrosion of the blocks.

One reply mentioned that insulation of the melting end might reduce convection currents in the glass to such a degree that the melting capacity might be reduced appreciably.

d.—*Refining end walls*

Most replies were in favor of insulating the flux walls of the refining end, there being 19 Ayes and 11 No's. Three of the affirmative replies specified the use of special blocks. Three other affirmative replies were based on their experience with the manufacture of sheet glass where insulation of part of the working end may be necessary in order to obtain a temperature high enough for working the glass properly.

ONE manufacturer recommended insulation only when glasses of low heat conductivity were being melted. Still another stated a favorable reply in case 8-inch blocks were used but advised against insulation of 12-inch blocks.

The negative replies mentioned the small heat saving, the increased wear on refractories, and the possibility of forming cords in the glass.

e.—*Melting end bottom*

Overwhelmingly negative—26 No, 1 Yes (qualified). The danger of glass going through joints, of blocks floating, of increased corrosion—these reasons coupled with the small possible heat saving caused the negative vote.

f.—*Refining end bottom*

Result of poll was 18 against and 9 for insulation. The opinion was that the heat saving was not enough to justify the expense and possibility of bad glass except in such furnaces where insulation is needed to maintain a suitable working temperature.

g.—*Regenerator walls*

Twenty-seven out of 30 were favorable to the insulation of regenerators, including walls, crown, bottom (and also flues).

h.—*Necks (Uptakes)*

TWENTY-TWO replies out of 27 voted "Yes." Four of these replies suggested the use of super-refractories.

i.—*Port walls*

The majority was against insulation of port walls (16 No; 11 Yes). The rapid burning-out of the brick influenced the negative voters. Among those who use insulation here, one manufacturer keeps insulation at least four feet away from the breast wall of the furnace.

j.—*Recuperator walls*

As expected, unanimously Yes (17 votes).

A summary of the replies to Question 1 is shown diagrammatically in Figure 1, which gives the percentage of replies favorable to the use of insulation.

2. *What parts of glass tanks have you insulated and what is your opinion of the results obtained (as regards fuel saving, life of refractories, etc.)?*

The previous question dealt with opinions, while Question No. 2 considers mainly what has actually been tried. The replies are given in the following summary which is largely in the form of direct quotations:

(1) One of the earliest experiments on the insulation of a full-sized glass tank which has been reported was tried about 13 years ago. This tank was insulated on the side walls with nine inches of insulating brick, while the bottom had three courses of fire-brick backed with three courses of insulating brick. The tank failed through an accident and, therefore, there was insufficient time for a study of the effect of insulation.

(2) Insulation which we applied to the refining end flux side walls in our furnace caused the blocks to run red hot all the way through. This condition permitted glass to penetrate the joints between the blocks and caused extreme corrosion. This practice was carried on for many years, but was discontinued a few years ago with beneficial results in decreased block corrosion and fewer cords.

We also insulate our regenerators.

In regard to insulation of flux side walls, it was stated in this reply that the results obtained from insulation are always affected by the many variables in the operation of the glass furnace. When a furnace is new and all walls are 12 inches or so thick, the insulation might have only a negligible effect. When corrosion reduces the walls to three inches or less, the effect of insulation would probably be great, and this is the maximum thickness of block where air cooling is of use in lowering the temperature of the inside of the block.

(3) We tried insulation of the flux walls in the melting and refining end several years ago. The whole

bottom was insulated also. At the end of three months the glass quality was so poor that we let out the tank. We insulate our recuperators and intend to place insulation on the crown in the melting and in the working end as well as on the side walls of the superstructure.

(4) We have insulated regenerator walls and regenerator crowns, working end flux walls, and working end crown. No accurate data as to fuel saving.

(5) We have insulated regenerators (crown, sidewalls, bottom) and flues. Also necks and ports. The fuel saving is about 10 or 15 per cent. Good refractories and insulation were chosen and they stand up well.

(6) The only parts of a glass tank which we have insulated are the flux side walls in the refining end. This was done to make it cooler for the machine operators. The insulation has been discontinued during the present fire to compare the effects on the refractories.

(7) Regenerators and necks have been insulated on several furnaces with fuel savings up to 5 per cent of total fuel. No effect on life of refractories. Infiltration of air is decreased. Waste gas temperatures (out of regenerator) may or may not increase depending on extent of fuel saving.

(8) We have insulated refiner side walls, regenerators, and ports. The refractories have lasted as long as before the use of insulation. We do not know the exact fuel saving due to varying pull on the tank.

(9) The use of insulated conditioning chambers for glass prior to working the metal gives a more uniform temperature to the mass of glass and produces ware of more exacting requirements as to size and thickness.

Refining end side walls were insulated satisfactorily using special refractories.

(10) We have the flux blocks in the working end all insulated as well as the walls up to the crown in an attempt to save fuel.

(11) Refining and flux side walls 12 inches thick were insulated with three-inch slabs. Life of blocks was not affected. No definite proof of fuel saving was found. Another similar tank had the refining end insulated with four-inch refractory blocks. Glass was wavy and insulation was removed, idea being to make glass in contact with blocks more viscous.

Another recuperative tank making about 12 tons a day had insulation on forehearth. Glass was wavy and cordy and insulation was removed. Some improvement resulted.

(12) Our records on fuel saving are not conclusive since our previous experience was on smaller tanks. Then we melted 1 ton of glass per .85 ton of coal. Now we melt one ton glass on .4 ton coal at maximum capacity. We have had but little deterioration of refractories through the use of insulation.

(13) We insulated regenerator walls without bad effects on refractories. No exact data on fuel consumption. The refining end bottom was insulated and the glass worked badly.

(14) We have several refining end crowns insulated. These units show some savings in fuel, and improved our temperature conditions for machine operation.

(15) Insulation of our regenerator walls made possible a fuel saving of about 5 per cent.

(16) We have insulated the flux side walls of the melting end of a tank and found increased corrosion and no appreciable difference in fuel. We always insulate recuperator and regenerator walls to benefit from higher preheating temperature.

(17) Melting end side walls were insulated (100-ton tank) with little if any fuel saving. Increased wear took place at the joints, all of which were left uncovered. Regenerator walls were insulated for fuel saving. No effect on life of refractories.

(18) The refining end crown, the melting end crown (beyond second port), the refining end flux side walls, the refining end bottom, the regenerator walls, and the necks were insulated on a 40-ton regenerative tank. About 5—10 per cent fuel saving was noted. The life of the refractories was about the same with the exception of the silica crown which was materially increased. (This is the only reply which mentioned the possibility of increased life of the crown resulting from the use of insulation.)

(19) After applying insulation to ports and necks, an appreciable drop in fuel consumption was noted. The saving was attributed to the insulation, although some other changes which were made at the same time may have influenced the result.

(20) The working end of tank, the necks, and the regenerators are insulated. Some fuel saving and shorter refractory life. (140-ton tank)

(21) We have been insulating for many years the refining end flux side walls, regenerator walls, necks, and parts of the ports.

(22) We have insulated the regenerator chambers, refining end walls, and refining crown. The life of refractories was not affected. There was some fuel saving but the purpose of the insulation was to keep the temperature of the glass metal high enough for working. From this standpoint the insulation was quite valuable.

(23) Refining end crown, refining end flux side walls, necks, parts of port walls, regenerator walls were insulated. Life of refractories is not shortened if hot face temperatures are unchanged.

(24) It is our opinion that insulation is entirely practical on the working end where temperatures are low. We have insulated the crown, side walls, and bottom. It does not perceptibly shorten refractory life at these points and does assist in maintaining proper working conditions.

We have also insulated the regenerator walls. We feel that in addition to decreasing heat loss, we cut down cold air infiltration.

(25) We have insulated the drawing end of a (12-ton) tank, part of side walls and bottom to obtain proper temperature.

(26) It has been our experience that it is not advisable to insulate any parts of our tank (90-ton) other than the regenerator walls. Our past results with tank walls (flux or equivalent) have proved more satisfactory without either water jackets or other cooling media, with the exception of forced air blast. Our straight flux walls give 14 months service and the refining end is good for another run.

(27) We insulated the crown over the melting end on one tank and found that it had to be replaced after one fire instead of the usual three or four fires. Insulation on the necks had to be removed due to burning up the brick. We have insulated the entire refining end side

walls and halfway up the melting end side walls of our Corhart blocks. This insulation does not seem to shorten the life of Corhart blocks but does definitely shorten the life of clay blocks.

3. *Do you consider insulation of the refining end an aid to the homogeneity of glass?*

Replies which answered "Yes" to this question mentioned the following reasons for their opinions:

Insulation tends to give a more uniform temperature to the mass of glass in the refining end. It helps to eliminate channeling in the flow of the glass stream. Stagnant glass pockets in the tank are not so pronounced and the formation of devitrified glass is minimized. Cords, striae, etc., are reduced. One user favored complete insulation of the refining end—crown, bottom, and side walls—as an aid to homogeneity.

If the feed to the fabrication point is shallow (as in some sheet glass tanks), insulation should help to maintain homogeneous glass and should be used if there is a tendency toward stiff metal.

Some qualified answers were given. For example, one user mentioned that no difference was noticed when he insulated the refiner of his (bottle) tank, but he was using special blocks and had no similar trial with other flux blocks. The opinion was expressed that although insulation may keep the corners hotter and so prevent the formation of "dog-metal," the hotter parts of the tank are much more important as regards the production of homogeneous glass.

This same expression was used in several of the negative replies, namely, that if glass is properly melted, it will remain homogeneous in the refining end and so in this respect there is no advantage to the use of insulation. Among other negative replies, one stated that cordy glass developed after insulation was applied and this same tendency to cords and waves was noted in another factory where insulation was used to maintain a suitable working temperature.

Many replies were quite strongly in the negative. Insulation of the refining end was found to increase corrosion, especially at the joints between the blocks, and so detracted from homogeneity of the glass.

Proper mixing and melting of the batch were considered more important in obtaining homogeneous glass, as well as trying to maintain an even temperature throughout the refining end.

The promotion of convection currents due to the cooling of the side walls was considered to be important in producing homogeneity. From this standpoint, the use of cooling air would be more suitable than that of insulation, particularly if the tank was running on high load.

Another drawback to insulation of the refiner was that it did not allow for the retention of the heavy glass contaminated with clay and iron which usually collects on the bottom of the tank.

Summary: The opinions were quite evenly divided, ten replies being that homogeneity was increased by insulation of the refining end, five being that homogeneity would be affected only slightly, and nine being definitely opposed to the idea,—a total of 24 opinions.

A scene in the Ford Baton Rouge Plant. Workmen are inspecting safety glass.

PUBLICATIONS RECEIVED

Use of 8-Hydroxyquinoline in Determinations of Aluminum, Beryllium and Magnesium. Research Paper RP813. National Bureau of Standards.

Some Comments on the Refractories Industry. Technical Bulletin 59, American Refractories Institute, Pittsburgh.

Experimental Researches and Reports, Volume XVII, 1934. 383 pages. Price 7/6. Department of Glass Technology, The University of Sheffield.

The publication consists of twenty four articles collected from Glass Review, Glastechnische Berichte, Journal of the American Ceramic Society and the Journal of the Society of Glass Technology.

Eight of the papers are reviews of the year's progress and present status of work in fuels, furnaces, refractories, machines, chemical analysis, chemical testing, and measurement of physical properties. A report of investigation under the Glass Research Delegacy, and a report of the Glass Industry of Norway and Sweden are also included.

Methods for determining the constitution of glass are discussed by W. E. S. Turner and another paper on the subject of constitution deals with the volatility of Lithium oxide. Several papers deal with the rate of melting of glasses and the decomposition of batch materials.

Physical properties of glass are the subject of four original investigations which include thermal expansion, transition point, breaking strength and influence of temperatures on the bursting strength of glass.

Other papers include work with boric oxide, the alkalis and their effect on melting and physical properties, the distribution of temperature during pot archings and the permeability of refractory materials to gasses.—A. K. L.

Sands, Clays and Minerals. June 1935 issue. A. L. Curtis, Westmoor Laboratory, Chatteris, England. This issue totals 160 pages, and contains a number of interesting papers. Among these are "Zirconium and Its Uses," by L. Sanderson; "Difficulties in the Manufacture of Fire Brick," by C. R. F. Threlfall; "Silicosis in Industry," by Edgar Morton; "Magnesite and Magnesite Brick," by C. L. Rigby; and "Quartz Sand in Silica Brick Manufacture," by Prof. P. Budnikoff. "Milowite, An Uusual Form of Silica," by J. N. Wilson, presents some instructive information regarding a little known product.

D. OF C. REQUIRES SAFETY GLASS

A new ruling by the Commissioners of the District of Columbia, to take effect January 1, 1936, provides that all cars assembled or manufactured after that date must be equipped throughout with non-scatterable glass in order to be eligible for District licenses. Director of Traffic William H. Van Duzzor, who will enforce the new law, has informed a GLASS INDUSTRY correspondent that 4,000 new cars, trucks and buses, averaging 24,000 panes of glass, will be affected the first year alone. Old cars will not be forced to install this safety glass. The Capital City has more cars per family than any other city in the world—the most important "family," of course, being the Government with its vast fleets of diplomatic, army, naval, and other official automobiles.

One hundred twenty-five school buses, the largest single order ever placed, were delivered to the City of New York late in August. All the buses were equipped with safety glass.

MEDICINE DROPPERS AND HYDROMETERS

The Treasury Department has recently approved federal specifications for glass medicine droppers and hydrometers used by the various governmental departments. Comments on the specifications are invited, but must be received by September 19. Since these specifications affect all who manufacture or sell these items directly or indirectly to the Government, it is to their interest to scan the specifications carefully. Copies may be received by writing to the Federal Specifications Division, Room 751, Federal Warehouse, 9th and D Streets, S. W., Washington, D. C.

The Blenko Glass Co., Milton, W. Va. has adopted a new shipping container, so strikingly beautiful as to warrant comment. The background is a deep red, with the design printed in black and silver. Entirely aside from its major job of delivering the contents safely, the shipping case attracts attention—most favorably—wherever it may happen to be. The case was designed and engineered by the Hinde & Dauch Paper Co., Sandusky, O.

GLASS DIVISION SUMMER PROGRAM

THE Glass Division of the American Ceramic Society will hold its annual summer meeting at Hammondsport, N. Y. September 13 and 14. "Mechanical strength of glass and its resistance to thermal shock" will be the subject of the papers presented, making the program a follow-up of last year's symposium. Meetings will be held at Firemen's Hall, as before; a change in the program made necessary by the floods last month. Members will be housed in cottages on Lake Keuka, and in near-by hotels. On Saturday night a shore dinner will be given on the lake front to wind up the official program. Glass Division members who may not have attended last year and are unfamiliar with the route to Hammondsport should write to Samuel R. Scholes at Alfred University at once.

As an introduction to the problems which will be considered at the meeting, J. S. Gregorius, chairman of the Division, has written the following foreword:

The papers to be presented at the Summer Meeting of the Glass Division of the American Ceramic Society have for their scope the mechanical strength of glass and its resistance to thermal shock. It is to be hoped that these presentations will tend to clarify the definition and produce the groundwork that will, at least, initiate a common expression of values with the ultimate development of a standard technique of testing. The difficulties attending the immediate realization of this goal are properly recognized, and it is hoped that such recognition will in itself be the greatest force in guiding us to a satisfactory conclusion.

Glass fails or breaks when an applied stress exceeds its strength. Materials have compressive and tensile strengths which are not identical. The compressive strength of glass is, possibly, seventeen times greater than its tensile strength. The ratio may be even larger. To produce in a test specimen compressive stress with no counterpart of tensile stress requires that the object be compressed in a liquid medium. No commercial application of glass faces this condition. Any application of stress developed either mechanically or thermally, which bends, twists, or otherwise distorts the specimen, will produce tensile as well as compressive stresses. Hence glass failures or breaks can be assumed to occur always from a tension failure. From this it becomes apparent that the most permanent need is for a method of determining accurately the tensile strength of glass.

The application of tensile strength may be quite easily accomplished. This being granted, the selection of the form and conditions of the specimen and technique of testing becomes important.

Influence of Thermal History. The rate of temperature drop through the critical annealing range determines the magnitude of strain existing in the specimen at room temperature. This residual stress in a flat specimen at rest would be compression in the skin layers and tension in the core. Such a distribution would mean that in any bending test the force applied would first have to nullify the skin compression before the intrinsic strength of the glass would be involved. Should not the magnitude of residual stress in the test specimens be defined?

Chemical Heterogeneity. Poor mixed or improperly melted glass show evidence of chemical heterogeneity. This heterogeneity makes controlled annealing difficult. Should not a definition of tolerable heterogeneity be made?

Continuity of Surface. The well-known ability of a hardened steel wheel or a diamond to score glass, thus making breaking easy, emphasizes the need of selected test specimens. Should not test specimens be free of chips, spalls, vents and the like? Should they be specified ground, polished, or fire-polished?

Ratio of Surface to Mass. A fiber has a higher apparent tensile strength than a rod of the same material. A lath of a given breadth, length, and thin section has a higher apparent modulus of rupture value than a lath of similar breadth and length but with a thicker section. Does this not open a wide field of speculation? Does the skin structure of glass differ from the structure under the surface?

Rate of Load Application. Does fatigue enter into strength of glass? Does an instantaneous application of force give a lower or higher strength value than a slow application of force? Answers to these questions are necessary in establishing the proper technique of testing.

These may be only a few of the thoughts that occur in connection with this problem, but surely there is unanimity in the thought that the properties of mechanical strength of glass and its resistance to thermal shock are of close kinship and that there are many manifestations of irregularity of these properties that disturb our mental composure.

Should the 1935 Summer Meeting of the Glass Division initiate steps that will lead to the development of acceptable methods of test and interpretation, the effort will be commendable and the reward of accomplishment high.

ABSTRACTS OF PAPERS

1. **The Effect of Sustained Loading on the Strength of Electric Lamp Bulbs, *By F. W. Preston***

The effect of time and load on the strength of electrical lamp bulbs is discussed. Observations directed to determining the conditions affecting strength in an object, the shape of which is spherical, or approximately spherical, over the critical area are also made.

2. **The Effect of Sustained Loading on the Modulus of Rupture of Flat Glass, *By L. V. Black, Pittsburgh Plate Glass Co.***

This paper endeavors to show the effects of different rates of force application on the breaking strength of glass. The modulus of rupture is determined when the average load necessary to break a given specimen is applied at rates ranging from 10 seconds to 40 minutes. The effect of fatigue on the strength of glass is also investigated.

3. **Strength of Flat Glass under Uniform Loading, *By George B. Watkins and R. W. Wampler, Libbey-Owens-Ford Glass Co.***

Break tests have been conducted on flat glasses in both square and rectangular shapes by uniform loading

(hydraulic). Data thus obtained may serve as a guide for determining the proper size and thickness of glass when used structurally.

4. **Proposed Method for Measuring Tensile Strength of Glass, *By C. J. Phillips, Corning Glass Works.***

An improved cantilever bending device with double loading edges is described and has been used for measuring the tensile strength of borosilicate glass cane drawn without marvering. Results are given for groups of samples which were abraded, highly polished, untouched, and treated in the ordinary way. Although the initial stresses and loading rates were adjusted to the same basis, the presence of surface imperfections is shown by overall maximum to minimum stress variations from 26.0 to 167.0%.

5. **Some Factors Affecting the Impact Strength of Glass, *By James Bailey, Bailey & Sharp Co., Inc.***

The general use of glass for protection purposes both in moving vehicles and in goggles has made necessary certain impact tests for sheet glass. These usually take the form of tests wherein a steel ball is dropped through a certain height upon the glass to be tested. The energy required to break the glass is not constant but depends upon several factors such as the kind of support, the size of the ball, the stiffness of the glass, etc. A small ball moving at high velocity causes a concoidal fracture driven through from the top side; a large ball with slow velocity causes failure in pure tension at the lower side. With large thin sheets and moderate velocity of impact the chief resistance to movement is caused by the inertia of the glass itself and the character of the edge support is no longer a factor. The investigation was confined to commercially annealed sheet glass.

6. **Modulus of Rupture and Thermal-Shock Resistance at Elevated Temperatures, *By J. S. Gregorius, Pittsburgh Plate Glass Co.***

The modulus of rupture of glass was observed at room temperature and at intervals up to 1000°F. The resistance of specimens to thermal shock was observed when the chilling medium ranged from 200 to 1000°F. Interpretations are drawn from the data observed.

7. **Thermal Endurance of Different Types of Flat Glass with Relation to Thickness, *By R. W. Wampler and George B. Watkins, Libbey-Owens-Ford Glass Co.***

Thermal-shock tests have been conducted on 3-inch squares of different types of flat glass by quenching samples in water at 32°F from a predetermined elevated temperature. Attempts have been made to correlate data thus obtained with heat absorption characteristics and thermal expansion coefficients.

8. **The Influence of Various Heating and Cooling Media on the Severity of Thermal Shock on Glass, *By R. G. Hunter, Owens-Illinois Glass Co.***

In order to determine the severity of thermal shock in its relation to the various substances employed in heating and cooling the glass, the following liquids were used: water, glycerine, ethylene glycol, and several oils. Further tests were made from hot air to cold air and hot air to cold water. The protective action of the hot liquid film adhering to the surface of the specimen was checked by comparing the relative severity of shock of two oils having the same thermal properties, but different viscosities. In all cases a 50% breakage level was used for comparison.

9. **Influence of Various Factors on the Results of Thermal Shock Tests, *By W. M. Hampton, England.***

10. **Review of Recent Literature on Strength of Glass under Sustained Loading with Particular Reference to Borchard's Work, *By J. T. Littleton, Corning Glass Works.***

Breakage of glass has been considered to take place as soon as a certain stress has been attained, or as soon as a certain strain is acquired. Results are cited which show that glass under sustained load breaks at about 50% of the stress which would be required at short time loads. This result is explained by the flowage in the glass under load, the flowage being greater around flaws than elsewhere.

OTHER A. C. S. DIVISION MEETINGS

The Refractories Division will hold its summer meeting at the Center Hills Country Club, near State College, Pa., on September 20 and 21. The subject for discussion will be "Present Problems and Trends in Refractory Requirements." The meeting will open with a luncheon at 12:30. At 2 o'clock, the technical session will be introduced with papers by Louis A. Smith, Jones & Laughlin Steel Co., and Harold E. Simpson, Battelle Memorial Institute. Other metallurgists will also participate. There will be an outing for "Pittsburgh Clay Workers Club" in the evening, with special entertainment for the ladies. Saturday will be given over to golf, tennis, swimming and other sports.

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For the first time, the White Wares Division will hold a summer meeting which is scheduled for September 6-7 at the Engleside Hotel, Beach Haven, N. J. Technical sessions will be held in the morning, with the afternoons and evenings devoted to entertainment.

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The Art Division meets October 28 and 29 at Syracuse, New York. These dates coincide with the Fourth Annual Robineau Memorial Ceramic Exhibition, held at the Museum of Fine Arts. The program will consist of round table discussions; no formal papers will be read.

FELDSPAR PRODUCTION IN 1934

In 1934 the output of crude feldspar in the United States was 154,188 long tons, valued at $853,136. This is an increase of 2.4 per cent in quantity and 9.5 per cent in value over the preceding year. The increase came mostly from the small producing states, as three of the four large producing states showed declines. Output of ground feldspar showed heavier gains than the crude, indicating large withdrawals of crude accumulated during 1933. Tonnage of ground feldspar increased 8.4 per cent and its value increased 15.5 per cent.

NOTES ON THE FABRICATION OF CONTAINERS

By G. B. LANGER

POOR fabricating conditions and sloppy methods of operation, not to mention certain "wild cat" designs utilized in the manufacture of glass containers by certain plants, has impelled the writer, a practical mold designer, to make a few suggestions to production men. Much of the material is neither new nor revolutionary, but it may be of assistance to them none the less.

Although the method of charging the batch to the furnace is usually considered of little concern to the man in charge of the "hot end," he should realize that it has a direct bearing on many of his fabrication difficulties, and consequently of real interest to him. If the batch is fed into the furnace at long intervals and in big charges, the temperature of the glass and the glass level in the feeder will vary and successful fabrication will be difficult and, in many cases, well nigh impossible without many feeder and machine adjustments. On the other hand, if the batch is charged in at regular intervals, or if a mechanical batch feeder is employed, such difficulties will be decreased or entirely eliminated.

Regularity in furnace reversal periods will also help in eliminating temperature fluctuations in the feeder.

In the feeder itself, it is important to secure the proper glass temperature for the job being worked. Once it is obtained, every precaution should be taken to hold the temperature constant. It is not at all unusual to see feeders operating under such poorly controlled temperature that instead of the glass charges issuing from the orifice vertically, as it should, the temperature difference between the back and the front of the "gob" is so great as to cause the "gob" to curve very definitely in the shape of an arc. By "condition of charge of glass" is meant the relative temperatures of the "surface skin" and the center of the mass. Of course this temperature differential appears to vary considerably in different feeders and in molds of given designs. The importance of the feeder temperature control is illustrated by the increasing use of pyrometer devices for this purpose.

AVOIDING SETTLE WAVES

After leaving the feeder, the glass "gob" should be charged into the mold as quickly as possible and as close to the first fabricating operation as the particular machine permits. This will avoid the formation of a cool skin, which causes an uneven distribution of glass or a "settle wave," as it is commonly known, which is very difficult to reheat or to eliminate, especially in connection with the brilliancy of the finished article. If the charge is properly shaped and deposited into the mold in a compact mass so that no folding occurs and with a minimum of settling, radical "wild cat" designs will tend to disappear.

The fabricating machine is generally blamed for any or all of the defects in the finished product. Usually, however, the machine itself is blameless. If anything does go wrong with the machine, a correctly trained operator will always detect certain warnings which will allow him to act in time and prevent too great an amount of "off-ware." More often, faulty mold design is responsible for poor fabrication. In the blow and blow type of machine and, to a lesser extent, in the press and blow type the fault usually lies in the parison design. Frequently, when running down the cause of poor fabrication, it will not be necessary to search beyond this point.

If the machine continues to produce "off-ware," even after the mold equipment has been corrected and all other "on the surface" possibilities have been eliminated, the machine should be stopped and a thorough examination made of the parts of the machine which at first glance would not appear to cause the faults. For example, the air passages or the vacuum circuit should be examined for blockage. These passages sometimes clog while the machine is idle.

"OFF WARE" OFTEN DUE TO HANDLING

As for the mold equipment, too little attention is paid to its care in handling and storage; the result is that a good percentage of the "off-ware" can usually be traced to mold defects caused by rough treatment or dirty molds. It is a good plan to build practical tools for the dismantling of the hot molds from the machine so as to prevent accidents to the man or the mold. A mold dropped on the floor is nearly always another job for the mold repair division. As the molds come from the machine they should immediately be cleaned, oiled and placed in storage instead of being left on the factory floor until they are damaged.

The development of practical tools for the regulation of the glass fabricating machine, while helping to prevent accidents to both man and machine, will also assist the operators in their work and save appreciable time. Such tools should always be kept in one place near the machine and the operators of the machine held responsible for them.

Even with excellent fabricating equipment, good production can never be attained if the operators are disinterested. The operators should be trained to take an interest not only in the production attained by themselves but also in the production attained by the previous shifts. Notes on machine performance, types of defects encountered during the run, and etc. should be compared with the men on the previous shift. Both the operators and the staff in charge of production should carefully study the construction and operating instructions of the fabricating machines in use.

If in doubt about machine limitations, it is always best to consult freely with the company furnishing the equipment. Their vast experience gained through research and actual practice enables them to give you a service that cannot be obtained elsewhere. This is especially true when new developments are offered. Such developments are nearly always concerned with the production of better ware and should be given careful study and consideration, as their cost may be largely compensated for by their advantages.

CHEMICALS ACCELERATE MELTING

(*Continued from page* 273)

Considerable interest is being shown in the use of barium salts as accelerators. As there is a scarcity of published work on this property of barium, considerable contradictory claims are being made in the industry. Zschacke, Hoffler and Riaza[12], in their study of the influence of BaO on the properties of technical glasses, show that when BaO is substituted for CaO in the absence of nitre in the following glass: 72 $S:O_2$, 18 Na_2O, 10 RO, more rapid melting and refining was obtained. In the presence of nitre the glass containing 2.5 per cent of BaO was the best as regards refining. When BaO was substituted for CaO in the glass 6.75 O_2, 13 Na_2O, 20 RO, the melting time was not affected but the refining time was reduced. A writer in Glashutte[13] suggests the use of barium nitrate as a refining agent because it does not decompose as readily as the alkali nitrates.

The analysis of various container glass shows the presence of BaO in amounts varying between 0.25 and 1.00 per cent with 0.50 per cent being the average. In most cases the BaO is introduced as a sulphate although several special barium mixes are in use. While there is a lack of published information on the effects of such small amounts of barium in glass, a consideration of its chemical properties in relation to other glass oxides indicates that it may decrease the durability of the glass to some extent and, if added as the sulphate, may cause decoloration troubles.

Among the many other materials that have been suggested as accelerators are sodium chloride, the use of a mixture of potash and soda, and hydrous calcium sulphate. Damour and Nadell[14] have shown that sodium chloride assists the refining of glass to some extent. Although sodium chloride has been used in the past as a cure-all for a multitude of glass ills, no other mention of its use as an accelerator has been recorded. Maskill and Turner[15] have found that a faster melting glass is obtained if both K_2O and Na_2O are present in the glass. Fastest melting is obtained in a glass containing 75 SO_2, 10 CaO, 15 (R_2O), when the alkali is combined as 7.5 Na_2O + 7.5 K_2O or as 5 Na_2O + 10 K_2O. The main disadvantage of using this method of acceleration is the high cost of the K_2O required.

It is claimed that hydrous calcium sulphate is a useful refining accelerator due to its peculiar gas forming properties. At temperatures between 400°F and 2000°F water is given off and at about 2200°F the anhydrous calcium sulphate decomposes with the release of sulphur trioxide. The liberation of this water and sulphur trioxide promotes a stirring action and assists in clearing the glass of seeds. An additional advantage in the use of this material is that the CaO so introduced will tend to increase the durability of the glass. A disadvantage may be in the effect of the sulphur trioxide on the decolorization process. Sufficient information is not as yet available and a detailed account of the possibilities of this material cannot be given.

[1] Jour. Amer. Soc., 1930, 13, 341. [2] Jour. Soc. Glass Tech., 1934, 18, 69, 13. [3] Keram. Rundschau, 1932, 40, 375. [4] Jour. Soc. Glass Tech., 1935, 19, 73, 40. [5] Jour. Soc. Glass Tech., 1928, 12, 46, 134. [6] Glashutte, 1931, 62, 441. [7] Jour. Soc. Glass Tech., 1931, 15, 58, 153. [8] Jour. Soc. Glass Tech., 1931, 15, 56, 166. [9] Keram. i. Steklo, 1934, 1, 23. [10] The Glass Industry, 1932, 13, 90. [11] The Glass Industry, 1933, 14, 33. [12] Keram. Rundschau, 1932, 40, 534. [13] Glashutte, 1933, 63, 373. [14] Chim. et Ind., 1932, 28, 1283. [15] Jour. Soc. Glass Tech., 1935, 18, 72, 134-136.

MAIL BAG

Editor, THE GLASS INDUSTRY:

Professor Taylor's article entitled "The Adherence of Glass to Metals" in the August, 1935 issue, has been read with a great deal of interest.

The subject of "wetting" of metals to glass is one of extreme importance in all incandescent lamp and thermonic tube work. A considerable amount of practical data exists but no correlation or theoretical explanation of this phenomena so far attempted is satisfactory.

In the paper I notice the following sentence: "Some workers recommend a slightly higher coefficient of expansion for the metal since this results in keeping the glass in compression which is the strongest condition—."

This is really a statement of present practice for it has been found that no other combination will stand up to commercial use. However, I think the reasons given for the use of the higher expansion metal is at fault for with the higher expansion metal, the glass immediately around the metal or the glass to metal junction is in tension and not compression, and therefore is not in its strongest condition. This can easily be verified by a polariscope.

This results from the fact that the metal, being of higher expansion, shrinks more on cooling than the glass, thereby tending to make a hole in the glass. This tendency is resisted by the glass to metal junction and results in tension in the glass immediately at the metal. The commercial success of the seal then, depends upon the strength of the glass and how firmly it "wets" the metal.

It is necessary to note that if the metal expansion is much greater than the glass, leaky seals result; if it matches perfectly, spiral cracks occur; if too small, the glass is crushed and shattered.

The above is but a sketchy summary of the points involved for the thermal history of the joint, and the relative rates of cooling of glass and metal play a large part in commercial practice.

H. K. Richardson,
WESTINGHOUSE LAMP COMPANY.

Editor, THE GLASS INDUSTRY:

Mr. Richardson's comments are of considerable interest in the general problem of stress at the glass-metal interface. I am of the opinion that it is necessary always to specify the direction of stress. If the metal has shrunk more on cooling than has the glass, there will develop a tension perpendicular to the interface, i.e., a radial tension; while at right angles to this the glass itself will be in compression, i.e., a tangential compression. This latter aspect is desirable since it confers strength on the glass itself. In order that the radial tension be insufficient to open a crack the glass must firmly wet the metal. This "wetting" is the main theme of my paper. That heat treatment of the seal also plays a very important role in developing or reducing stresses is shown by J. T. Littleton, J. Am. Ceram. Soc. 18, 239-245 (1935).

Nelson W. Taylor.
PENNSYLVANIA STATE COLLEGE.

L-O-F. OPENS DEPARTMENT FOR "NEW USES AND DESIGN"

Libbey-Owens-Ford Glass Co., Toledo, Ohio, has just inaugurated a "New Uses and Design" department. Kenneth C. May and Harold M. Alexander, will be in charge. The new department will specialize in creating and developing new uses for flat glass in its rapidly increasing field of appreciation, due to improvements and new kinds of glass now being manufactured by the Company.

USE OF SELENIUM FOR DECOLORIZING GLASS*

AT THE present time selenium is the most commonly used decolorizing agent in glass manufacture. None the less, this very unstable substance frequently gives rise to misconceptions: it is not unusual to discover that the decolorizing of a glass of constant composition demands, at times, quantities of selenium that vary capriciously from one day to the next; perhaps, one obtains a glass of a more or less brownish tint, a color contrasting very unfavorably with the sparkle of a true "flint" or "crystal" glass[1]: in other circumstances, a glass, perfectly decolorized in the melting furnace, acquires a certain amount of color in the annealing lehr.

The decolorizing of glass is undoubtedly one of the most difficult phases of the art of glass making, for the raw materials employed invariably contain oxide of iron in varying amounts. In addition, the containers in which the glass is melted (pots or tanks) give up to it, in equally varying proportions, sundry impurities, oxide of iron among them. According to its degree of oxidation, iron confers on glass a yellow-green or a blue-green tint[2]. The coloring power of Fe_2O_3 (ferric oxide) is less than that of FeO (ferrous oxide). In practice, we are always dealing with an indeterminate mixture of the two oxides, and as each of them colors the glass differently, the choice of decolorizing agents and the amount to use, remain matters of a complex and conflicting character.

Two methods of decolorizing are recognized: first, the chemical way, which usually consists in modifying the degree of oxidation of the color-bearing substances, iron, selenium, manganese, etc. (for instance, by causing the iron to pass from the ferrous to the ferric state). Other reactions are however equally possible, and some writers assume that in the presence of common salt (NaCl), part of the iron is driven off as iron chloride ($FeCl_3$). Fluorine would work in a similar fashion, and would favor the decolorizing of the glass as a consequence of the reduction of iron-content. This first procedure is entirely governed by chemical equilibria: the reversibility of certain reactions makes their study very difficult.

Secondly, we have the physical procedures, wherein we add to the glass the complementary tint to that which it possesses in the first instance. The chemical method "clarifies" the glass, while the physical treatment merely "tones" or "counterbalances"[3] its tint by adding a new color, and it follows that in the latter case we get a complementary absorption of the light passing through.

If on the one hand, the very complex chemical process of decolorizing still escapes us in part, and if on the other hand we consider the great number of different glass mixtures used in industry, the variety of our raw materials and of their impurities, and the various melting conditions of each different furnace, it is easily seen that it may be impossible to lay down absolute rules for a method of decolorizing, capable of satisfying all requirements of present day practice.

Thus, in the case of a pot furnace whose heating is not uniform, we are obliged to add different amounts of decolorizing material to the different pots, in spite of the fact that they all contain exactly the same batch: those pots which are exposed to a higher or lower temperature than the average need a greater proportion of decolorizer than those in which the glass melting is carried out "normally." Moreover, we ought to give attention to the corrosion of the pot walls: this diminishes as time goes on, so that the quantity of iron introduced from this source into the glass becomes less after the pot has been in use for some time: this accordingly demands a readjustment from time to time of the amount of decolorizer.

It was in 1894 that Kopp in America obtained for the first time selenium ruby glass: he observed also that this element (selenium), used in small quantities, could act as a decolorizing agent for glass. The use of selenium spread first in the United States, then was introduced in Europe largely as a result of the work of Turner on the subject. Formerly, "metallic" selenium was used almost exclusively: in more recent times, certain compounds of selenium have been substituted.

SELENIUM

BELOW are the properties of selenium and of the principal selenium compounds in present day use for decolorizing glass:

1. *Metallic Selenium*: an amorphous variety of elementary selenium, black in color. A fairly pure substance analyzing 97 per cent selenium (Se), 2 per cent water (H_2O), and 1 per cent miscellaneous impurities. Softens around 100°C, liquefies at 217°C, begins to boil around 670°C. Heated in the presence of air, it burns and oxidizes to selenium anhydride (SeO_2).

2. *Selenium Red*: another amorphous variety of elementary selenium, red in color. On gentle heating at about 100°C, it turns into the foregoing black variety, and from this point onwards possesses the same physico-chemical properties.

3. *Sodium Selenite*: Na_2SeO_3. A very hygroscopic salt, soluble in water, containing about 45 per cent selenium. In the presence of reducing agents (coal dust for instance), it readily alters at room temperatures and liberates selenium of the red variety. Volatile at high temperatures. Its decolorizing power, according to the English writings, is thirty times that of elementary selenium.

4. *Barium Selenite.* $BaSeO_3$. A salt not soluble in water and not hygroscopic. Not completely volatile short of 1200°C. Contains about 29 per cent selenium.

5. *Selenite of Zinc.* $ZnSeO_3$. Contains 39 per cent or thereabouts of selenium: likewise volatile at high temperatures.

The volatility of selenium and its compounds is a very important factor which makes its proportioning to the mix very uncertain and its results problematical. Turner found that the greater part of the selenium escaped during the melting process, the glass retaining only a relatively small proportion, around 23 per cent.

Note. Since this was translated, the March 1935 issue of the Journal of the Society of Glass Technology has appeared with an important article by Gooding and Murgatroyd on Selenium Decolorising. This likewise gives an excellent digest of the literature, which in recent years has become quite extensive. The present account by "R. D. & L. F." should preferably be read in conjunction with the Scholes transcript of footnote 7 and the Gooding and Murgatroyd article referred to above.

In the course of experiments on the subject, Knapp[4] obtained the following results:

Table I. Volatilized Selenium

Substance	Selenium volatilized after 30 mins. at 1000°C	60 mins. at 1000°C
Se	99.1	100.0
Na_2 Se O_3	21.9	22.2
Ba Se O_3	15.7	16.0
Zn Se O_3	59.3	70.3

On this basis we find that barium selenite is more stable at high temperatures than the other substances.

THE results give simply the loss of weight from substances heated at 1000°C. But during this thermal treatment, chemical reactions may have occurred, for instance, selenites may have dissociated or may have oxidized to selenates. For this reason the author also determined the amount of selenium remaining in each residue. The values found are given in the table below:

Table II. Selenium

Substance	Selenium In the residue	Volatilized
Se	0.0%	100%
Na_2Se O_3	31.9	30
Ba Se O_3	17.8	40
Zn Se O_3	17.2	62

These figures indicate that sodium selenite is the substance that releases the lowest proportion of selenium.

In a third series of tests carried out at a higher temperature (1200°C), the author observes that the volatility of sodium selenite rises rapidly with temperature, while barium selenite scarcely varies at all.

Table III.

Substance	Selenium volatilized at 1200°C	
Se O_3 Na_2	48.4%	Compare with Table I
Se O_3 Ba	17.8	

It follows that barium selenite is the most stable of the substances studied.

However, the behavior of selenium compounds is different according as they are heated alone or in the presence of glass batches. In the former case, elementary selenium, for instance, is entirely volatilized at 1000°C: in the second case, on the other hand, the glass retains a certain amount even though the melting temperature may have been carried to 1400°C or more. It was therefore necessary to determine in what proportion selenium compounds are volatilized in the melting process. Mixtures of powdered glass and of the products in question were therefore heated for two hours at 1200°C and the following results obtained:

Substance	Volatility of Selenium
Se	74.8%
Se O_3 Na_2	57.7
Se O_3 Ba	16.6
Se O_3 Zn	30.5

The values thus obtained show that, in the case of glass melting also, barium selenite is the most stable compound. Chemical analysis of the glasses obtained likewise indicated that the proportion of selenium incorporated in the glass melt was higher when barium selenite was used. The foregoing considerations warrant the preference accorded to the latter product in modern industrial practice.

COLORS DEVELOPED IN GLASS BY SELENIUM COMPOUNDS

It is established that the red color is produced by elementary selenium, yet doubt remains as to the physical state in which this material is found in the glass. For a long time past it has been admitted that selenium was present in colloidal form, Fenaroli[5] having discovered in certain glasses, by examination in the ultra-microscope, particles of selenium some 40 mμ in diameter, separated by distances from 0.37 to 0.64 μ. (Particles about 1½ millionths of an inch in diameter spaced some 10 times this amount apart.)

In the case of gold and copper rubies, the color is produced by crystalline metallic particles of gold or copper which appear in the molten glass between 600 and 800°C: these particles may exist in the glass even in the neighborhood of 1000°C. The same cannot be true of selenium, since this element above 690°C is in the gaseous state, is liquid between 690 and 270°C, and only takes on the crystalline form below 270°C.

Hofler[6] has made a very important contribution to the study of this problem and his results are of great value in works practice.

He made numerous melting tests (more than 350) on soda and potash glasses, in a special electric furnace, so arranged that he could maintain in it, throughout the experiment, an atmosphere of known character. This furnace permitted him to reproduce time and time again, and every time under well defined conditions, the various investigations in the course of which he was able to study with precision the influence of furnace atmosphere on the color developed in glass by selenium. This tint varies greatly with the melting conditions, but it is practically always the same when these conditions are maintained constant.

Here for example are the results obtained on the following base glass:

Si O_2....74%, K_2 O....18%, Ca O....8%
Iron Content (Fe_2 O_3): 0.015 to 0.020%
Selenium Content (Se): 0.022%

In an oxidizing medium, the melt obtained was, after cooling, composed of two distinct layers. The upper layer (1/3 the total depth of the block of glass when the medium was oxygen, (O_2) was colorless: the second, deeper layer, was colored pink. This pink tint was pronounced, and resembled that given by an acid solution containing methyl orange.

In a neutral atmosphere (Argon, Nitrogen, Carbon Dioxide, Water Vapor, and Sulphur Dioxide) a pink glass is obtained throughout the whole mass. The upper colorless layer is missing, and the tint produced is a little more intense than in the previous case.

IN A reducing medium, the tint is salmon-pink, that is, shaded with brown, when the furnace atmosphere is nitrogen with 3 per cent carbon monoxide. When the CO content rises to 10 per cent, the glass becomes browner. In an atmosphere of pure carbon monoxide or pure hydrogen, the glass obtained shows a tint resembling the last, while at the same time there appears on the surface a new colorless zone.

All the different layers of glass thus prepared contained some selenium. It follows therefore that there

are two distinct varieties of selenium-bearing glass. With different gaseous media in contact with the glass during the melting process, one may obtain a glass,

Colorless, first variety, in a highly oxidizing medium
Pink, in a neutral medium
Reddish brown, in a slightly reducing medium
Colorless, second variety, in a strongly reducing medium

In another series of similar experiments, the author replaces elementary selenium with each of the following selenium compounds in turn:

Sodium Selenate....Na_2 Se O_4
Sodium Selenite....Na_2 Se O_3
Sodium Selenide....Na_2 Se

Varying with the compound used, the glasses showed the following properties:

In an Oxidizing Medium. With selenate or selenite, the thickness of the upper colorless layer (first variety) is greater than with elementary selenium. In the case of the selenide, the colorless layer is missing.

In a neutral atmosphere, the color is very uniform throughout, a pale pink with selenate or selenite, a pronounced pink with elementary selenium, a straightforward brown with selenide.

In a slightly reducing atmosphere, two layers of different colors, in the case of selenate and selenite; the upper layer (1/5 of the total thickness or depth of glass) a reddish brown; the lower layers pink. With elementary selenium or selenide, the tint is uniformly brownish throughout.

In a highly reducing medium, three layers of differently colored glass, in the case of selenate or selenite; at the bottom, a pink layer, at the top a colorless layer (second variety), and an intermediate brown zone. With selenium "metal" and with selenide, only two layers of different color are obtained: the lower layer brown, the upper layer colorless (second variety)[7].

As in the foregoing experiments, it is observed that the tint produced in the glass varies according to the degree of oxidation of the selenium, and that it may pass from the first colorless variety to pink, then to brown, and finally disappear in the second colorless variety, the purest tint being always given by elementary selenium, in a neutral medium.

IN BRIEF, a glass in which elementary selenium for instance, is introduced, will take on a pinkish cast under neutral conditions. If the molten glass be maintained awhile in an oxidizing atmosphere, the upper layer of the glass becomes colorless (first variety): by holding awhile in a reducing atmosphere, the color tends first to brown and then to disappear in the surface layers (second colorless variety).

If the heat treatment be sufficiently prolonged, in any given atmosphere, the selenium passes through different degrees of oxidation. The variation of color, in glasses colored with elementary selenium, are very rapid, and the final tint is on that account always uncertain.

Selenite behaves a little differently from elementary selenium. Under oxidizing conditions it does not color the glass (first colorless variety); in a reducing medium it gives first a pinkish coloration, and if the reducing action is continued, the surface layers tend to turn brown and may ultimately reach the second colorless state. The oxygen reserve provided by the sodium selenite therefore opposes a too rapid reduction of this selenium compound, and the tint obtained is more stable in this case than when elementary selenium is used. This is why in practice preference is given to the selenites.

The selenide on the contrary nearly always colors the glass brown. Under the influence of an oxidizing medium, the tint tends to pink and finally to the first colorless variety: the same thing occurs with a reducing medium, where we get a colorless glass of the second variety. Hence the selenide resists more or less well an oxidizing action, that is, it resists going over into a pink coloration: its natural tendency is to color the glass brown.

Let it be noted however, that the resistance of selenite to reduction and that of selenide to oxidation is merely a matter of time, and that in the long run the influence of the atmosphere prevails over that of the initial state of the selenium.

WHEN the glass contains only a very small amount of selenium, the latter is quickly transformed into one of the two colorless compounds. The influence of the atmosphere is less marked in proportion as the selenium content of the glass is increased: hence the color produced is more stable in the selenium-red glasses, with a large amount of selenium used, than with glasses in which the selenium is merely a decolorizing agent.

Large variations of temperature are without notable effect on the selenium compounds herein contemplated, while the stirring of the molten glass increases appreciably the oxidizing or reducing effects of the furnace atmosphere. Convection currents also have a profound influence on the speed of the reactions affecting the state of the selenium. This accounts for the fact that in practice even small variations of furnace atmosphere are quite important.

Certain substances entering into the composition of the batch mixtures are likewise endowed with very energetic chemical properties (oxidizing or reducing), and in consequence react with the selenium compounds in the same fashion as does the furnace atmosphere: As_2O_3 and KNO_3 favor a pink or colorless (first variety) glass, while carbon tends to produce the colorless second variety. The action of these substances is usually rapid and not very enduring, whereas the furnace atmosphere requires rather a long time for its full effect to be felt, but finally predominates.

The introduction in the mix of 0.2 per cent of Na_2O in the form of sulphate (salt cake) has no influence on the behavior of selenium or selenium compounds.

Certain natural products, particularly sand and limestone, commonly contain a variety of impurities, among which it is by no means rare to encounter reducing substances (carbon or hydrocarbons); these reducing materials are very active, for on the one hand they are spread more uniformly throughout the mix than can be the case with carbon (such as coal, graphite, or charcoal) sometimes added to the batch, and on the other hand their complete destruction calls for a prolonged roasting.

Wiegand[8] and his co-workers prepared a number of glasses starting with the following batch:—

SiO_2—Sand from Dorentrup "OPB" containing 0.0069% Fe_2O_3—100 parts
Na_2O—Soda Car. Kahlbaum analytical 0.0002% Fe_2O_3— 37 parts

CaO—Carbonate of Lime. Merck. 0.0007% Fe_2O_3— 24 parts

Se—Sodium Selenite. Merck. Enough to ensure 0.0025% Se in the

final glass, whose per cent composition was 74% SiO_2: 16% Na_2O: 10% CaO.[9]

Various samples of the sand were given a preliminary roasting for 30 minutes at different temperatures, before using them in the glass batches. The table below gives the result of the experiments.

Roasting Temp. of Sand	Color obtained in the glass
Not roasted	Typical pink of Se glasses
Roasted at 700°C	Pale pink
Roasted at 1000°C	Very pale pink
Roasted at 1200°C	Nearly colorless
Roasted at 1400°C	Quite colorless

It may be observed that the variations of tint and the order of their succession agree with Hofler's results.

On the other hand, Wiegand, experimenting on batch mixtures to which different amounts of carbon had been added, obtained the following results:

A. The tint obtained is the more intense the more carbon is used.

B. Over a certain range, the color of the glass is very strongly influenced by a small increase in the proportion of carbon.

C. Beyond a certain upper limit, an increase in the carbon produces at first scarcely any change of color; then the color weakens and finally disappears.

The glasses which Wiegand obtained when starting out with chemically pure materials were always colorless: on adding 0.017 per cent of pure ferric oxide, the glass remains colorless. But on substituting for pure silica (i. e. for silica precipitated from silicon tetrafluoride) commercial sands, invariably containing some reducing substances, the glasses produced were colored, the tint varying from pink to deep brown.

In practice, it is rare to find a furnace whose atmosphere is unequivocally oxidizing in normal operation, since the usual melting conditions, derived from tradition and confirmed by theoretical considerations are characterized by a long flame (clear but not sharp), filling practically the whole of the combustion space and licking more or less the surface of the glass bath[10]. In consequence it is not necessary to contemplate the addition of carbon to the batch with a view to offsetting the action of a permanent oxidizing medium. Indeed, in order to avoid developing in the glass the very distasteful brownish tint, it is essential to add to the mix some oxidizing agents in order to destroy the organic matters which naturally occur there and to offset the reducing action of the furnace gases.

The rate of cooling has no influence on the initial coloring of the glass: we are referring, it must be understood, to the cooling of the glass during the shaping of an article, and not of the annealing of the said object. There has not been observed, furthermore, any clear-cut relation between the color of the glass and the melting temperature.

Soda glasses show the same phenomena as potash glasses, except that their color is generally paler and also a little more brownish than the corresponding potash glasses.

On the other hand, as the proportions of the batch are modified, it is observed that the acid glasses give a clearer and purer tint than basic ones.

To sum up, the various colors produced in glasses correspond to different degrees of oxidation of selenium. These colors are increasingly unstable in proportion as:-

1. a strongly oxidizing or strongly reducing atmosphere is used,
2. the chemical resistance of the selenium compound used is lower,
3. the length of time the chemical action is kept up,
4. the amount of selenium in the glass is lower,
5. the temperature is raised (in laboratory tests)
6. the stirring of the melt is more vigorous.

As regards the behavior of selenium during annealing: the greater part of industrial glasses are subjected, after fabrication, to an annealing process, and during this heat treatment changes of color may be produced. These changes of color are very marked in glasses containing a high percentage of iron.

The following experiment, recorded by Hofler, is as ingenious as it is interesting. Hofler superposed two sheets of glass, one colored green by iron oxide (0.1 per cent approx. of Fe_2O_3) and the other colored pink by selenium (a few thousandths per cent of Se): the green and pink tints together produced a neutral grey. Then, melting the two glasses together, he obtained a glass which after cooling was of a very pronounced reddish-brown color. The author (Hofler) assumes that a combination has taken place between the selenium and the iron, forming iron selenide for example. While the green and pink tints taken separately, are stable, that of the new compound (Fe Se) is on the contrary very unstable, and varies with the method of cooling: cooled quickly, it is nearly colorless: reheated or maintained awhile in the range 700-600°C, it takes on a pink or red-brown color, depending on the length of the treatment. It follows that the final color depends on a chemical equilibrium: above 700°C the iron selenide (if that is in fact the substance involved) is decomposed by the alkalis or alkaline earths, or perhaps is simply dissociated: below 500°C, the viscosity of the glass is such that new chemical equilibria are nearly impossible. The coloring power of iron selenide being much greater than that of elementary selenium, the tint developed in the glass is more than enough to compensate for the green color arising from the iron oxide.

It follows that during the annealing process, the color of selenium glasses is subject to variations, if the thermal conditions in the kiln or lehr are not maintained constant, as a result of the possible displacement of the chemical equilibrium governing the formation of iron selenide. A steady time-temperature curve is therefore a most important factor in the kiln operation.

Variations of color in annealing are particularly noticeable when the glass contains at the same time large amounts of selenium, iron oxide, and arsenic. Under these conditions, it is, so to speak, impossible to produce with a given glass, objects of varying wall thickness with a uniform color in all parts, because the heat treatment of the lehr cannot be made suitable for both the thick and thin parts.

Furthermore it is important to observe also that the chemical equilibria called forth by certain thermal treatments (fire-polishing, annealing, etc.) normally affect the entire mass, while in the case of glasses decolorized with

manganese, for instance, these reactions affect only the surface layers and on that account make but a small difference to the color of the glass.

Conclusion. The following remarks, formulated by Turner, have not lost any of their importance: To obtain a water-white glass it is necessary

1. To use raw materials of a very pure character, and to make certain that their iron content does not vary,
2. To use always the same amount of decolorizer, except when it is intended definitely to make a change in that particular,
3. To use enough arsenic, but not too much,
4. To do the melting in a relatively short time,
5. To avoid keeping the glass at a high temperature for an extravagant length of time.

Amount of Selenium to be used: 1. To decolorize glass containing 0.04 to 0.06 per cent of Fe_2O_3, it is necessary to add from about 2/3 of an ounce to a whole ounce of selenium per ton of sand (2000 lb.).

2. Since sodium selenite is about thirty times as powerful as elementary selenium, it will be sufficient to add 1/15 to 1/10 of an ounce of this substance per ton of sand.

3. If barium selenite be used, the quantity will be from 1/10 to 1/6 of an ounce per ton of sand.

According to Turner, it is best to add 3 lb. of arsenic to a ton of sand. The quantity of arsenic used should not be less than 50 times the amount of selenium.

Remarks. Soft, easily melted glasses, retain a larger proportion of the selenium than hard glasses.

Don't stir up the glass with arsenic thrown into the melt, for this results in additional arsenic which may affect the color during annealing.

The furnace atmosphere should be neutral or slightly oxidizing.

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* Translated by F. W. Preston from Verre et Silicates Industriels, p. 118 of Vol. VI. April 10, 1935, et. seq. (Note. The original article is signed simply "R. D. & L. F.")

[1] The French word is "white". There is no English word of unambiguous meaning which, when referring to glass, means "sparkling and colorless". F. W. P.

[2] More strictly, blue when the glass is thoroughly "reduced". F. W. P.

[3] French "virer", "to go on the other tack".

[4] Dr. Ing. O. Knapp. Die Fluchtigkeit der technischen Selenpraparate beim Gluhen und Glasschmelzen, *"Keramische Rundschau"*, 1931, No. 43.

[5] Fenaroli, "Chem. Ztg.", 1912 & 1914; "Kolloid, Ztsch.", 1915.

[6] W. Hofler. Ueber das Verhalten des Selens im Glase. *"Glastechn." Ber.* 1934, No. 4.

[7] A more extensive digest of Hofler's work appears (in English) in GLASS INDUSTRY for July, 1934, p. 122. (Translated by S. R. Scholes.) F. W. P.

[8] Wiegand, Dietzel u. Zschimmer. Ueber den Einfluss des Kohlenstoffgehaltes typischer Kristallglassande auf die Selenfarbung des Glases. *"Sprechsaal"*, 1934, No. 35 to 38.

[9] Fairly close to a typical American bottle glass. F. W. P.

[10] Melting in a closed pot must be considered an exceptional case.

DETERMINATION OF BORIC OXIDE IN GLASS*

In a note in Technical News Bulletin 206 (June, 1934) a modified method for the determination of boric oxide in glass was outlined. Since then it has been found that the final para-nitrophenol end point is not always sharp enough to give satisfactory results. This condition apparently results either from small amounts of impurity in the ether or from allowing the alkaline ether-alcohol solution to stand too long before complete removal of the ether and alcohol.

Impurities in the ether were successfully removed by passing it in a very fine stream through alkaline permanganate of potash (adapted from Palkin and Watkins, Ind. Eng. Chem. 21, 863 (Sept., 1929). The long contact is avoided by promptly removing the ether and alcohol by evaporation and subsequent boiling.

Instead of using 51.2 per cent of the proportional amount of boric oxide extracted by the 50 ml aliquot, it has been found more satisfactory to compute the boric oxide in the sample from the "distribution constant," which has been found to be 0.406. If A represents the amount of boric oxide, determined by titration, in 1 ml of the 50 mil aliquot of the ether-alcohol layer, $2.463A$ represents the amount of boric oxide in 1 ml of the water layer. The total boric oxide in the sample becomes the sum of the products of A times the total volume of the ether-alcohol layer, and $2.463A$ times the total volume of the water layer.

Following the above procedure, boric oxide has been determined in glasses and synthetic mixtures containing from 0.7 to 12.6 per cent with an average error of 0.08.

The method has been found satisfactory for all glasses studied except those containing zinc, barium, and flourine. These three elements interfere and cause low results.

* Technical News Bulletin No. 219, July 1935. National Bureau of Standards.

Kyanite. Preliminary reports from producers indicate that the demand for kyanite from the Southern States in 1935 has been well ahead of that in 1934 or previous years. Already the material is employed extensively in glasshouse refractories, tank blocks, and refractory cements as well as in a variety of special uses such as pyrometer tubes and other high-grade ceramic articles. Field work conducted in the summer of 1934 by the United States Geological Survey in cooperation with the Geological Survey of Georgia and the United States Bureau of Mines, with funds granted by the Public Works Administration, resulted in the discovery of a belt of kyanite schist 30 miles long which contains large reserves of kyanite. Preliminary tests show that the material could be concentrated readily into a high-grade product with an average yield of at least 1 ton of concentrate per 25 tons mined. Placer deposits 2 or 3 feet thick also occur in Georgia and contributed a small production of fairly pure crystals during the last year or two. The material has been shoveled directly into an ordinary sluice which was the only concentrating equipment. Operations in North Carolina have been expanded, and consideration is being given to reopening a Virginia property.—*From U. S. Bureau of Mines.*

Lepidolite. Fairly large supplies of lepidolite could be obtained in California, Colorado, South Dakota, perhaps other States, and Canada. Imports from Southwest Africa likewise may be developed extensively. Lithium oxide is considered an excellent flux for glass melts, and lithium glass is said to have a low melitng point, low annealing temperature, and characteristic optical properties. Lepidolite may be used also in the preparation of white and opalescent glasses and enamels (especially to prevent crazing of zincless glazes).—*From U. S. Bureau of Mines.*

Selenium. Ore containing selenium is reported to have been found in the neighborhood of the village of Tilkerove in the Harz Mountains, according to a report from vice consul David H. Buffum, Leipzig.

CURRENT PRICES OF GLASS-MAKING MATERIALS

FURNISHED BY PRODUCERS, MANUFACTURERS AND DEALERS

		Carlots	Less Carlots
Acid			
Citric (dom.)	lb.	...	.29
Hydrochloric (HCl) 20° tanks	Per 100 lb.		1.10
Hydrofluoric (HF) 60% (lead carboy)	lb.	...	.13½
52% and 48%	lb.	.10	.10-.11½
Nitric (HNO_3) 130 lb. carboy ext.	Per 100 lb.		5.50
Sulphuric (H_2SO_4) 66° tank cars	ton	15.50	...
Tartaric	lb.	Po. or Gr. / Cry.	.25 / .25½
Aluminum hydrate (Al $(OH)_3$)	lb.	.04-.04½	.04½-.05
Aluminum oxide (Al_2O_3)	lb.	.04	.05
Ammonium bicarbonate (f.o.b. works)	lb.	.0515	...
(f.o.b. N. Y.)	lb.	...	.0571
Ammonium bifluoride (NH_4FHF)	lb.	...	.14
Ammonium nitrate (NH_4NO_3)	lb.	...	.08
Ammonia water (NH_4OH) 26° drums	lb.	...	.02¼
Antimonate of Sodium	lb.	...	.10½
Antimony oxide (Sb_2O_3)	lb.	...	.12¼
Antimony sulphide (Sb_2S_3)	lb.	...	.13
Arsenic trioxide (As_2O_3) (dense white) 99%	lb.	.03½	.04-.04½
Barium carbonate ($BaCO_3$), Crude, (Witherite) 90%, 99% through 200 mesh	ton	40.00	45.00
90% through 100 mesh	ton	37.00	...
Barium hydrate ($Ba(OH)_2$)	lb.	.049	.05½
Barium nitrate ($Ba(NO_3)_2$)	lb.	...	.07¾
Barium selenite ($BaSeO_3$)	lb.	...	1.50-1.75
Barium sulphate, in bags	ton	19.00	24.00
Barium sulphate, glassmaker's, carlots, bulk f. o. b. shipping point	ton	15.00-16.00	18.00
Bone ash	lb.	.06	.06½
Borax ($Na_2B_4O_7 10H_2O$)	lb.	...	...
Granulated	In bags, lb.	.022	.0245-.027
Powdered	In bags, lb.	.0245	.027-.0295
Boric acid (H_3BO_3) granulated	In bags, lb.	.05	.0525-.055
Cadmium sulphide (CdS)—	lb.	...	.70-.75
Calcium phosphate ($Ca_3(PO_4)_2$)	lb.	.07	.07½
Chromite	lb.	...	.0215
Cerium hydrate 100 lb. drums and 600 lb. barrels	lb.	...	.65
Chrome Oxide Green, 400 lb. bbls.	lb.	.17	.215-.25
Cobalt oxide (Co_2O_3) In bbls.	lb	...	1.39
In 10 lb. tins	lb.	...	1.49
Copper oxide Red (Cu_2O)	lb.	...	.25
Black (CuO)	lb.	...	.15
Black prepared	lb.	..	.22
Cryolite ($Na_3Al\ F_6$) Natural Greenland (Kryolith)	lb.	.08½	.09
Synthetic (Artificial)	lb.	.08	.08½
Epsom salts ($MgSO_4$) (imported) technical	Per 100 lb.	...	2.30
Feldspar— 20 mesh	ton	11.00-13.25	
40 mesh	ton	11.50-13.75	
Granular	ton	11.75-14.00	
Semi-granular	ton	11.00-13.25	
L. C. L., (Min. 2 tons) $3.00 per ton additional plus charge for bags			
Fluorspar (CaF_2) domestic, ground, 96-98% (max SiO_2, 2½%) Bulk, carloads, f. o. b. mines	ton	30.50	...
In bags	ton	32.10	38.00-40.60
Formaldehyde, bbls.	lb.	...	.07
Graphite (C)	lb.	...	.04-.07
Iron oxide— Red (Fe_2O_3)	lb.	...	.0425
Black (Fe_3O_4)	lb.	.04½	...
Iron chromate	lb.	...	.035-.05
Kaolin (f. o. b. mine)	ton	8.00-9.00	...
English, lump, f. o. b. New York	ton	14.50-25.00	24.50-30.00
Kryolith (see Cryolite)			
Lead chromate ($PbCrO_4$)	lb.	...	.16
Lead oxide (Pb_3O_4) (red lead) (N. Y.)	lb.	.0685	...
In 5 Ton lots	lb.	...	.07¼
Less than 5 Tons	lb.	...	.07¾

		Carlots	Less Carlots
Lime— Hydrated ($Ca(OH)_2$) (in paper sacks)	ton	10.50	...
Burnt (CaO) ground, in bulk	ton	7.00	...
Burnt, ground, in paper sacks	ton	9.00	...
Burnt, ground, in 280 lb. bbls.	Per bbl.	2.25	2.25
Limestone ($CaCO_3$)	ton	1.75-2.50	...
Litharge (PbO) (New York Prices)	lb.	.0585	...
In 5 Ton lots	lb.	...	.06¼
Less than 5 Tons	lb.	...	.06¾
Magnesium carbonate ($MgCO_3$)	lb.	.06	.08-.09
Magnesium sulphate (U.S.P.)	lb.	...	.0265
Manganese, Black Oxide In Paper bags	ton	45.00	50.00
In Burlap bags	ton	46.50	51.50
In Casks	ton	48.00	53.00
Neodymidm oxalate, 50 lb. drums	lb.	...	5.00
Nickel oxide (Ni_2O_3), black	lb.	...	.35-.40
Nickel monoxide (NiO), green	lb.	...	.35-.40
Plaster of Paris, bags	ton	31.00	23.00-29.00
Potassium bichromate ($K_2Cr_2O_7$)— Crystals	lb.	...	.08½
Powdered	lb.	...	.09½
Potassium carbonate Calcined (K_2CO_3) 96-98%	lb.	.06⅞	.07⅜
Hydrated 80-85%	lb.	.06	.06¼-.06⅜
Potassium chromate (K_2CrO_4) 450 lb. bbls.	lb.	...	.16
Potassium hydrate (KOH) (caustic potash)	lb.	.06¼-.06½	.08-.08½
Potassium nitrate (KNO_3) (gran.)	lb.	...	.06-.06¼
Potassium permanganate ($KMnO_4$)	lb.	...	.19
Powder blue	lb.	...	.18¾
Rare earth hydrate 100 lb. drums	lb.	...	.35
325 lb. barrels	lb.	...	.36
Rochelle salts, bbls.	lb.	...	.12½
Rouge	lb.	Po. or Gr. / Cry.	.13½
Rutile (TiO_2) powdered, 95%	lb.	.10-.12	.13-.15
Salt cake, glassmakers (Na_2SO_4)	ton	18.00	27.00
Selenium (Se) In 100 lb. lots	lb.	...	2.00
In lesser quantities	lb.	...	2.10
Silver nitrate ($AgNO_3$) . (100 oz. bot.) per oz.		...	.39
Soda ash (Na_2CO_3) dense, 58%— Bulk	Flat Per 100 lb.	1.10	...
In barrels	Per 100 lb.	1.50	...
In bags	Per 100 lb.	1.25	...
Sodium bichromate ($Na_2Cr_2O_7$)	lb.	.06½	.06¾
Sodium chromate ($Na_2CrO_4 10H_2O$)	lb.	...	.08
Sodium fluosilicate (Na_2SiF_6)	lb.	.04¾	.05¼
Sodium hydrate (NaOH) (caustic soda) Flake	Per 100 lb.	3.00	...
Solid	Per 100 lb.	2.60	...
Sodium nitrate ($NaNO_3$)— Refined (gran.) in bbls.	Per 100 lb.	...	2.00-2.25
95% and 97% Bulk	Per 100 lb.	1.175	...
200 lb bags		1.24	1.29
100 lb. bags		1.275	1.325
Sodium selenite (Na_2SeO_3)	lb.	..	1.80-2.00
Sodium uranate (Na_2UO_4) Orange	lb.	...	1.50-1.55
Yellow	lb.	...	1.50-1.55
Sodium uranyl carbonate	lb.	...	.80-.90
Sulphur (S)— Flowers, in bbls.	Per 100 lb.	3.35	3.70-4.10
Flowers, in bags	Per 100 lb.	3.00	3.35-3.75
Flour, heavy, in 250 lb. bbls.	Per 100 lb.	2.90	3.25-3.65
Tin chloride ($SnCl_2$) (crystals) in bbls.	lb.	...	.37½
Tin oxide (SnO_2) in bbls.	lb.	...	.54
Uranium oxide (UO_2) (black, 96% U_3O_8) 100 lb. lots. Black	lb.	...	3.00
Yellow orange	lb.	...	1.50
Zinc oxide (ZnO) American process, Bags	lb.	.0575	.06
White Seal, 150 lb. bbls.	lb.	.10¾	.10⅞
Green Seal bags	lb.	.09¾	.09⅝
Red Seal, bags	lb.	.08¾	.08⅝
Zircon Granular (Milled .005-.02c higher)		.07	.67½-.08
Crude. Gran. (Milled .005-.02c higher)		.03½	.04-.07

EQUIPMENT AND SUPPLIES

NEW LYNCH MACHINE

A new bottle forming machine known as model "J-P-L" has been recently introduced to the trade by the Lynch Corporation, Anderson, Ind.

The "J-P-L" machine has been designed for the production of quarts, half-gallons or other similar articles up to and including wide mouth gallon containers. The machine accommodates 12 blank molds and 12 blow molds, and is the largest machine ever manufactured by the company.

The machine is of the Geneva movement and requires a five H.P. motor for the operation of the mechanism. The intermittent motion employed brings each mold in turn beneath the plunger, as well as any other given point. The plunger is actuated by the piston of a pressing cylinder. The parison after forming is then transferred to the finishing mold in the same manner as is now employed on the "J-P" and "J-P-M" machines. The article is then blown to final shape. All movements are timed and synchronized to function automatically.

The new "J-P-L" machine is not an experimental machine but is the result of experiences gained through the performance of two other machines of similar design. The new machine embodies the same simplicity and smoothness of operation as the three Lynch and Miller machines now in successful use.

The C. O. Bartlett and Snow Company, manufacturers of material handling and processing equipment, Cleveland, Ohio, has announced the appointment of Mr. W. A. Meddick to a position in the Sales Department. Mr. Meddick will have charge of the company's sales of Mixers, Air Filters and accessory lines. He was formerly Manager of the Industrial Department of The Lakewood Engineering Company, and later District Representative for a group of selected manufacturers.

NEW AIR OPERATED CONTROLLERS

The Brown Instrument Company announces a new and complete line of Recording and Indicating air operated controllers for temperature, flow, pressure and liquid level.

The most outstanding of these is the Brown "Air-o-Line," a controller with 1 to 150 per cent throttling range and automatic reset. This control system recognizes and corrects for the magnitude, rate and direction of departure from the control point. These instruments are capable of full automatic control and will maintain a process at the control point within extremely close limits.

Indicating and recording thermometer-type temperature controllers are available for temperatures within limits of —40°F. and +1200°F. Potentiometer-type controllers are available for temperatures within limits of —300°F. and +3400°F.

AUTOMATIC TROUBLE SHOOTER

An annunciator unit, which automatically signals any abnormal condition in temperature, pressure, movement of bodies, flow, speed, etc., occurring in any part of the factory, has been developed by the Kellogg Switchboard & Supply Co., Chicago. From the literature outlining its uses and operation, the company evidently believes the device is particularly well adapted for use in glass factories; as, for example, to give instant notice of any deviation from desired heat conditions. Warnings are conveyed by signal light, alarm bell, or any desired method, and the location of the trouble is indicated on the annunciator panel.

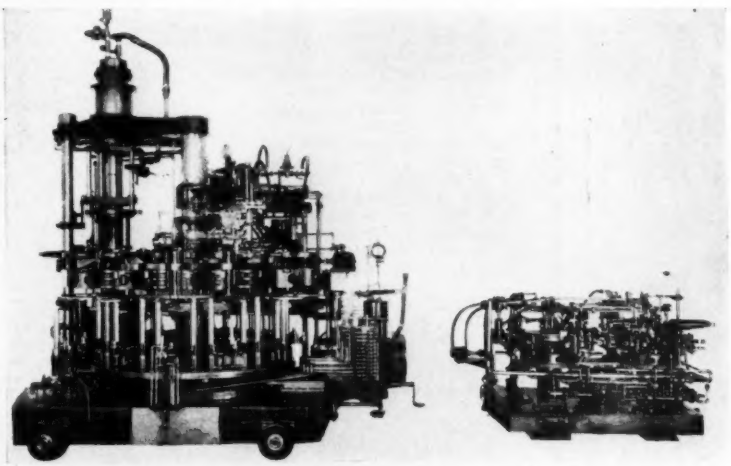
CATALOGS RECEIVED

Audabon Wire Cloth. Catalog 41. Audabon Wire Cloth Corp., Philadelphia. Describing the complete line of flexible wire cloth made by this company, including specifications, list prices and tables of useful information.

The Power Specialist. Johns-Manville, N. Y. The June number of this smart little house organ begins a series of six articles dealing with asbestos and asbestos products. The first article is of a general historical nature about the raw material itself. Succeeding numbers will treat with the development and uses of specific products. Obtainable on request.

Pneumatic Tires for Wheelbarrows and Trucks. B. F. Goodrich Co., Akron, O. A four page folder giving specifications, outlines of their advantages in meeting various work problems, and illustrations of their successful application.

Laboratory Microscopes. Bausch & Lomb Optical Co., Rochester, N. Y. The microscopes described and illustrated in this booklet are for use with any manner of work on transparent or translucent specimens where vertical light is not required. Accessories and illuminating systems are also fully described.



The smallest Lynch machine ever made looks up to its big brother—the largest and newest machine of the Lynch family.

CONCERNING TUCKSTONES

(*Continued from page* 269)

the accessibility for cooling and hot repairs is poor although cooling is not considered absolutely necessary with some of these materials. The casting of the block in one piece would not materially increase the overall cost and in this type of construction is not a detriment. Two faults which have not been found in previous connections must be considered: first; that the ear would doubtless break off during heating and although this might not seriously affect its life, it would possibly prevent the use of this construction; and second, due to the lack of flexibility between the blocks and the silica sidewall, the expansion of the bottom may cause the top to tip over. The latter is such a serious defect that the construction is not recommended.

(h). This construction is similar to (g). The ear has been removed from the block and a silica support has been provided which partially fulfills the major requirement. The accessibility for cooling and hot repairs has been greatly increased by turning the leg of the supporting angle upward. The block is simple and the construction is to be preferred to (g). The possibility of the block tipping still remains and this drawback may be overcome by leaving about one half inch expansion space between the silica sidewall and the block. This space should be filled in after the tank has been brought up to the operating temperature. Such a change would place this construction on the recommended list. (*Concluded in the October* GLASS INDUSTRY)

MR. RENDALL'S SERIAL DELAYED

Due to circumstances beyond his control, Mr. W. Stanley Rendall was unable to furnish THE GLASS INDUSTRY with the third installment of "Economic Problems of the Glass Industry" which he has been writing for serial publication. The series will be resumed in October.

G. C. A. FALL MEETING

The Glass Container Association will hold its annual Fall meeting at the Hotel Traymore, Atlantic City, Thursday, September 19 and Friday the 20th. Proceedings will open Thursday morning with a general meeting. In the afternoon a golf tournament will be held, followed by an informal dinner that evening. Friday will be reserved for group meetings.

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Defects in Glass By C. J. Peddle	$6.00
Electrical Properties of Glass By J. T. Littleton and G. Morey	3.00
Glass By Percival Marston	1.00
Ceramics (a handbook) By A. Malinowsky	3.00
Ceramic Tests and Calculations By Prof. A. I. Andrews	2.25
Decorative Glass Processes By A. L. Duthrie	3.00
Industrial Furnaces (Vol. 1)	6.00
Industrial Furnaces (Vol. 2) By W. Trinks	5.50
Fuels and Their Combustion By Haslam and Russell	7.50
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The Glass Industry

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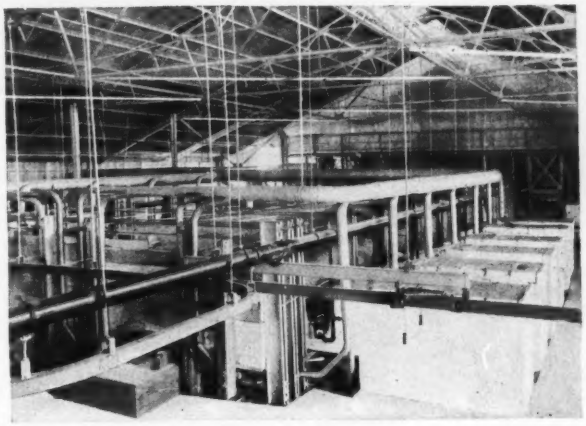
KIRK & BLUM
Blower Systems



K & B Improved Tank Cooling System installed in plant of Scohy Sheet Glass Co., Sistersville, W. Va. Note streamline fittings and long radius elbows—features that assure greater air pressure with less power.

K & B Cooling Systems Pay for Themselves

Kirk & Blum Cooling Systems reduce power costs, prolong the life of the tank, minimize replacements, increase production. Records from installations in many of the larger glass manufacturing plants throughout the country show that because of the savings thus effected, K & B Blower Systems soon pay for themselves.
Our engineers will, without any obligation, analyze your cooling problem and advise where and how savings, if any, may be made.

Tank and machine building of Scohy Sheet Glass Co., Sistersville, W. Va.

THE KIRK & BLUM MFG. CO.
2804 Spring Grove Ave., Cincinnati, Ohio

Chicago Office: 3843 N. Central Park Ave.
Detroit: D. H. Baird Co., 9143 Central Ave.
Pittsburgh: The Bushnell Machinery Co., 1501 Grant Bldg.
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